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An Illustrated Weekly Journal

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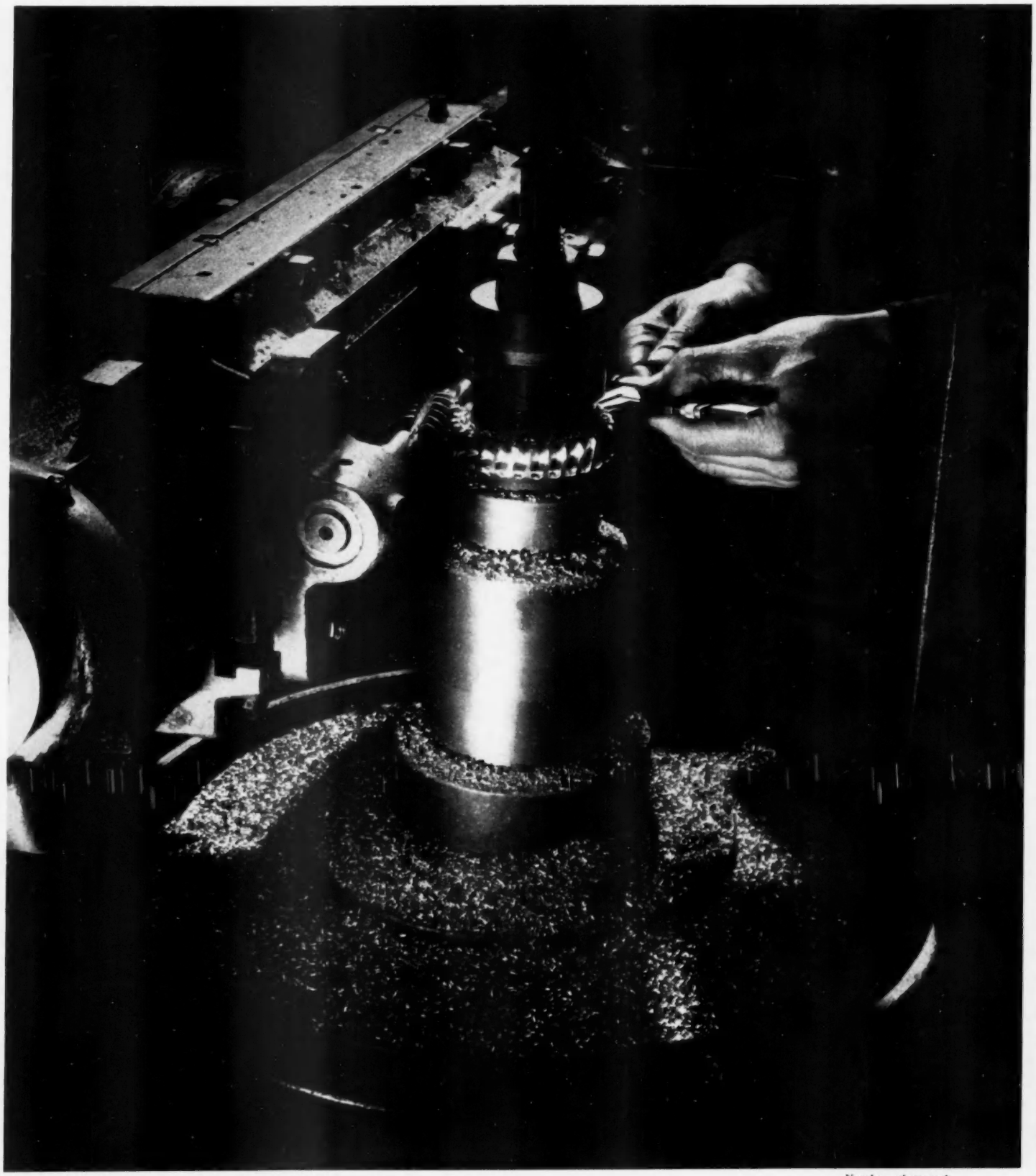

CHECKING A THROATED WORM WHEEL

Nurnberg photograph for ENGINEERING

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FROM DEFENCE TO ATTACK

FOR too long now Britain has paid too heavy a price for the defence of the West and made too unequal a sacrifice. Our ability to sell goods in world markets has suffered in consequence and we have lost ground to those of our competitors who bear a lighter burden. We have been spending one-tenth of the gross national product on defence; 7 per cent. of the working population are either in the Services or supporting them.

The task ahead has been defined. It is an all-out attack on the economic problems that beset the country. The balance of payments has to be put on a really firm footing, to encourage further progress in industrial investment. This in turn will make possible further improvements in living standards. The Budget proposals are being announced as we go to press. There is little doubt they will include the kind of tax reliefs which will enable the leaders and managers in industry to concentrate on achieving the economic task. There can be no wholesale relaxation of restrictions on consumption at home, but those who bear the greatest responsibility must be freed from the nagging worry of making ends meet. We cannot afford greatly increased expenditure on plant and equipment but equally there is a need to spend more than is projected for this year. The cuts in defence, though unlikely to amount to more than £79 million, will help to achieve these objectives.

The reductions in expenditure foreshadowed in the Defence White Paper total £217 million. Under the new plan, we shall spend £1,483 million compared with £1,700 million envisaged under last year's programme. Inflation, however, and reductions in the amounts contributed by the United States and Germany will cut down the net savings by nearly 65 per cent. The savings which are of greatest immediate concern to manufacturing industry are in the amounts spent on defence production and research. After deducting the expected American aid, about £535 million will be spent this year—a net reduction of over £27 million on the 1956-57 level. The bulk of the cuts will fall on production and research for the Army and the Navy. The amount spent for the Air Force will be little changed.

Speaking at the Cutlers' Feast in Sheffield last week-end, the Prime Minister took great pains to tell his audience that the defence cuts would be most unlikely to create dislocations and unemployment in the metal and metal-using industries. There is, he said, " a vast quantity of work waiting to be done . . . The needs therefore which the Government and the nation must meet to-day are simple. First, a sound defence policy with armaments adequate indeed, but not so massive as to crush the economy; secondly, an increase in our exports."

The Economic Survey has revealed that a large number of companies in manufacturing industry were under-employed last year. The output of manufactures was lower than in 1955, though there was a substantial increase in productive capacity. Yet, apart from the large motor companies most leading firms in the metals and engineering industries achieved a level of output substantially higher in 1956 than in 1955. The inference is that many engineering firms were under-employed, and that a large gap exists between the leading companies and the rest of the industry. If the under-employed were also those firms who do not much concern themselves with export then there is every justification for the Government's moves to increase competition by removing restrictive practices and lowering import barriers. However painful it proves to be, the cobwebs must be swept away. The world abhorrence of nuclear war is gradually asserting itself and forcing the governments of the great powers to extend their influence in the developing countries of the world through economic power. Dams, power stations, steel works, harbours and other means of achieving industrial status are becoming the bargaining levers that once were a cruiser's visit or a military ultimatum.

Such trends provide Britain with a unique opportunity to re-establish the dominance that was once hers in world affairs. We are more dependent than most on the import of raw materials and food. We must therefore secure our supplies by providing those countries who have what we need with the necessary plant and equipment to exploit their natural resources and to build up for themselves the industrial basis for a higher standard of living. This, the Government have seen clearly. They have admitted that Britain cannot be defended against nuclear attack and that the presence of British troops abroad makes more difficult rather than easier the co-operation of those countries which supply us. Therefore we shall in future concentrate our work on atomic weapons to the deterring of aggression, and we shall meet local troubles overseas by a mobile central reserve at home. The provision of fast planes for its transport is likely to cost far less than large permanent garrisons, and the investment in good will their withdrawals represent is not to be despised.

Thus the country's policy in world affairs has seen in the few months of the Macmillan Government a greater radical change than in 35 years of varied rule. The objectives are clear, and the means to achieve them

becoming more clearly defined. Above all, it is to become competitive in world markets and to re-establish ourselves as the world's number one supplier of capital goods. On the export front, we must attack.

* * *

Plain Words

Planners have always turned to Russia as the apotheosis of centralised state control. These protagonists of so-called orderly development have usually seen only the virtues of the system.

It is a source of some comfort that the inspiration of "1984" and the much-publicised paradise of the mass-produced technician is also a source of comic relief—even if of the grimmer sort. It has required Mr. Krushchev, with his reputed sense of humour and hence sense of proportion, to show up the excesses of centralisation. In his 20,000-word document which is to be presented before the Supreme Soviet next month he has hard things to say about the inefficiencies of over-centralisation and the need to decentralise authority to the regional level. Under his new system, the State Planning Commission in Moscow will set the over-all plan, but national economic councils will be set up in the 15 constituent republics of the Union and in each industrially important area within each republic.

If one wanted to see the dangers of over-enthusiastic economic planning one would instinctively go to Russia. Those who were involved in Britain's planning exercises during and after the war, with its puny population of less than 50 million people, can well imagine the excesses of misplaced zeal, empire-building, ministerial jealousies and form-filling for its own sake which a structure the size of Russia could develop. It is apparent from Mr. Krushchev's statement that all the difficulties of a vast administrative machine, which the absence of efficient checks perpetuates, are there displayed. Great swings take place in planning targets and output which make management of industrial units a nightmare. Raw materials and even labour are moved over vast distances when they are wanted in the next street. Co-operation between ministries becomes a political haggle. The absurd becomes the normal and commonplace because the administrative machine persuades those in power that it is more important than the things it produces.

Mr. Krushchev is perhaps on the verge of a great thought. He has shrunk from a battle with political theory on state planning. He has seen the confusion of over-centralisation and, on paper, proposes the introduction of a measure of local control. The relation of the central authority to these local organisations has still to be worked out and the local units themselves are vast enough to perpetuate confusion. Shaw once said that a certain British institution existed to perpetuate "snobbery, jobbery, incompetence and red tape." It is beginning to look as though Shaw and Mr. Krushchev have more in common than either might have thought.

PROBLEMS OF FILM MAKING

Films are used in industry to enlighten, interpret or persuade. Their value lies first in the forcefulness and directness of the visual image, and second in their property of condensing into a few minutes the work and preparation of many weeks. For this reason they provide a clearer and more concise account than could otherwise be attempted. In the present article two well known directors of documentary films discuss the filming of scientific and technical subjects. Mr. Basil Wright will be best remembered for his work on Song of Ceylon, Night Mail, *and, more recently,* World Without End, *which he made in collaboration with Paul Rotha. Mr. Strasser is well known for his work as an expositional film maker of great ingenuity and imagination. Among the many films he has directed are* Your Children's Eyes, Creatures of Comfort *and* Mirror in the Sky, *a film for schools on the ionosphere.*

*By Alex Strasser and Basil Wright**

There are no hard and fast rules in filming. Almost every new film brings new problems; and it is this variety of purpose and method which makes film-making so enjoyable and fascinating. Nevertheless, some sort of routine is indispensable. Each film must be scripted, shot and edited. It is in the amount of time and thought spent on each of these stages, in the formulas of presentation, and in the techniques employed, that the secret of successful film production must be sought.

Let us look at a production from the point of view of its creative demands. We shall soon see that the shaping of a film occurs mainly in the scripting, and that "scripting" is by no means limited to the script-writing stage. It usually starts with an investigation into the subject matter and virtually continues right through the entire production. Editing is really nothing but another phase of scripting. Thus, film-making seems to be on the whole a mental process which has to be interrupted from time to time by the mechanical necessities of getting one's ideas on to celluloid. If people try to skip proper scripting, the result is as devastating as it is costly.

There are three distinct stages before the actual production of a scientific film can begin: (1) assembly of all material relevant to the subject (*investigation*); (2) selection and elimination (*treatment*); and (3) arrangement of the matter with a view to its presentation in visuals and sounds (*shooting script*). It is important to realise at the outset that the more time and care are given to this relatively inexpensive preparatory phase, the quicker will the production pass through the shooting stage, which swallows most of the money.

As it is difficult to generalise—there being hundreds of variations and possibilities in making films—it seems best to have a specific example in mind: say, a sponsored educational film, dealing with an intricate scientific-technical subject. The procedure might then be as follows:

Investigation

No film-maker can be expected to be an expert in all the jobs he is asked to tackle. Thus, having been briefed, he must try to acquaint himself with the subject. The technical advisers who are to be consulted are usually nominated by the sponsor. When meeting them, it is just as well to give the impression that one knows a little about the matter in hand. Therefore, the first step is to go to the nearest technical library and take home some books. A few days study will usually provide a general idea of the subject and its general background; but its value is fairly limited. What is most important is the specific aspect of the subject for which the film is to be designed. This must be discussed with the specialists.

The nominated adviser is usually a well-known personality with a great reputation in his own field, a professor or the head of a research department of a big firm, extremely busy and sometimes a little hard of hearing. It often takes some time before he can spare a few minutes for an interview, and since these few minutes are most likely the only opportunity the fim maker will ever have of talking to him (mind you, he will be received in a most cordial manner!), the one really vital thing to ask him is for an introduction to another adviser on a less exalted level. This request will result in the appearance of the professor's assistant or a member of his research team, and from then on the path is relatively smooth. Much of the work of scientists is monotonous and they are often glad of a little interruption of their daily routine, particularly if it takes them to a good restaurant.

Important to nearly every investigation are the visits to the actual locations in which the film, or part of it, is to be shot. Naturally, they can vary enormously in size and type, but they are usually industrial plants, laboratories, hospitals, workshops and the like, situated in widely scattered areas; these visits may take a few hours, or several days. The people to consult are not so much the heads of the firms, but rather the works managers or foremen who have an unsurpassed knowledge not only of the hour-to-hour routine in the works, but also of every technical detail. They are the people on whom later much of the smooth shooting of the film will depend.

These interviews and visits may well repeat themselves, with variations, for a number of weeks (or even months) and for as many times as the subject may require. In the case of an educational film, the investigation has to cover the teaching as well as the technical or scientific aspects. All the information gleaned from these visits and interviews, from books and journals, from existing films and any other sources, has now to be collated and welded together into a written report. The origin of each piece of information should be stated, and to this end the report should be well indexed.

Treatment

The investigation-report forms the basis for the treatment of the film. This is a short document recommending how much of the assembled material should be incorporated in the film, and in what manner. The reasons for selecting certain items and for rejecting others should be given. The guiding points for this are the greater or lesser relevancy of each item to the story, their suitability for visual presentation, and how much space there is for their inclusion. Thus, the approximate length of the film and the way in which the story is to be told, must already be considered at this stage.

Shooting Script

As soon as the treatment is approved by the sponsor (of whom more anon), the shooting script can be written. This is the stage where the foundations for a good or bad film are laid. A shooting script is like a musical score which no number of brilliant musicians can bring to life if it is dull and unimaginative. The writer has now to make up his mind how to present his subject. According to the finance available, he has at his disposal a number of technical aids such as colour, special photographic effects, camera movement (tracking and crane-shots), infra-red and high-speed film stock, animated diagrams and cartoons, models, studio sets, miniature sets, and so on. In each medium he has usually the choice of several systems and techniques. On the sound side, the possibilities vary from a simple commentary track with canned play-in and play-out music to an intricate track combining commentary, synchronous dia-

* Realist Film Unit, 9 Great Chapel-street, London, W.1.

Reconstruction of Marconi's early experiments for the filming of "Mirror in the Sky." Much the greater part of film making lies in planning and preparation: before any camera work can be undertaken material must be assembled and inessentials eliminated, locations chosen and mock-ups built. The preparatory and shooting stages are to some extent represented by these two views, which show that the documentary film maker is not invariably confined to smoky cities.

logue, natural effects and specially composed music played by a reputable orchestra.

The writer's first task is to think of the visuals necessary to illustrate every point which the film has to cover. This is comparatively easy where the action takes place on the spot; it is not so easy where the film deals with abstruse theories, or where prolonged wordage is required without the possibility of dialogue (expense problems often confine one to commentary only).

The script writer therefore must not only have an intimate acquaintance with the techniques and methods available to film-makers; he must also be competent to weigh them against each other and decide in favour of those most suitable for the given purpose; and in addition he must know whether their use is permissible or possible within the limits of the budget, and must therefore be able to make a good estimate of the overall production cost. He must keep a proper balance between the various parts of the film, and must see to it that no component such as music, speech, or a visual sequence, is given an undue prominence which might confuse the issue. It goes without saying, therefore, that the writing of film scripts is a skilled job which, apart from a natural flair, needs years of practical experience in film making. Scientists or engineers who are amateur photographers or cinematographers frequently set about making films for their firms on the strength of their experience with the camera, and they are often successful in shooting scenes of people at work or of a technical process which, when joined together, can be an admirably instructive document. But it is a far cry from this to a full-scale production; camera work is only a small part of film making, in which scripting plays the major role, and this is definitely a job for experts.

The writing of a film-script may take anything from a week to several months according to subject and circumstances; and, like the investigation-report and the treatment, the shooting script will be gone through by the sponsor with a fine tooth-comb. Here, something must be said about the relationship between the film-maker and the sponsor.

The relationship is that of two sets of people who are trying hard to find out what is in the other's mind. The film maker must understand what the sponsor (the subject) demands from him, and the sponsor (or his technical advisers) must be able to recognise the subject matter in its filmic form. Though this task is difficult for both parties, it is more so for the subject experts. The film maker is, after all, given the time and facilities for a full investigation into the subject matter, whereas few subject-experts have ever been heard of investigating the intricacies of film production, even if, as is improbable, they would have the time to do so. Thus, when the treatment, and later the shooting script, are circulated among the various departments, committees and individuals who have a say in the matter, and when they are then counter-checked by probably another set of specialist advisers, strange things may happen. On one occasion a treatment which had been checked and approved by expert No. 1 was returned to the script writer by expert No. 2 with P-O-P-P-Y C-O-C-K scrawled in large letters right across the front page. But such extreme cases apart, the scripts usually come back to the film people with a large number of marginal comments and corrections which show how difficult it must be for "ordinary" people to read or appraise a film document. Many of these refer to small commentary points or unimportant details; the readers often cannot follow the descriptions of visuals and do not realise that at this stage the commentary must, of necessity, be scrappy. What the scriptwriter really wants to know is whether there are any structural faults, any vital omissions or wrong arguments. But defects of this kind are not easily recognised by the expert in the script; they seem to be obscured by the form in which a film story must be presented. Small, but obvious, blunders in terminology or factual details, however, catch the readers' eyes like glaring typing errors.

Of course, many suggestions and comments remain which are extremely valuable and which have to be met. Thus, treatments and shooting scripts have to be altered and re-written quite a number of times. As long as the parties understand each other's difficulties and the "gives" and "takes" are constructive, the relationship between film-maker and sponsor will remain happy and the film will benefit. The time and effort spent on improving the script are certainly never wasted. It is at this stage that the collaboration between the two parties must be closest; and this collaboration will be resumed during the final editing period, when the first screening of the rough cutting-copy of the film often reveals faults which had not been detected by the experts in the script (for the reasons mentioned above). But before we reach this stage, the film must be shot, and a wise sponsor, while giving every assistance he can, will leave the technicians largely to themselves during the shooting period.

The type of film we are discussing can usually be made by a comparatively small basic unit. But from time to time other technicians have to be called in—as for instance studio-crews, colour or microfilm specialists, diagram experts, special effects men, model makers, and so on. Then on the sound side there is the recording crew, one or more commentators, and perhaps a composer, a musical director and an orchestra.

As regards the "geography" of shooting, much of it may have to be done out of doors, in widely scattered places, under given circumstances, dependent perhaps on events which may be unrehearsable and unrepeatable. Interior shooting may take place in the studio (which requires set-building), or in the most diverse surroundings such as factories, restaurant kitchens, laboratories, college buildings, aeroplanes or crofters' cottages.

Lastly, there are the "facilities," from the lighting equipment needed for indoor location work, to, say, complicated tehcnical apparatus which is to be part of an experiment to be shown in the film (such as, maybe, an audio-spectrometer or the replica of some gadget used 60 years ago by Marconi). In addition, the script will require scores of small items, from a pink toothbrush to an old bicycle or a couple of centipedes.

All these items or individuals have to be traced, interviewed, engaged, briefed and co-ordinated. All the objects have to be found, bought, hired or otherwise procured. The duration of shooting has to be timed in detail, studios and locations arranged for, facilities laid on, transport organised, hotels booked. Each detail has to be brought in line with the others. After the last schedule is drawn up, one can only hope that no one will go down with 'flu, that the weather will be clement, that the cameras won't break down, that the experiments will work.

While the production manager and assistant director are coping with these arrangements, the director is busy with his own preparations. Again, his main pre-occupation will be with the visuals. Scenes or sequences can be shot in dozens of different ways: some call for clarity, big close-up photography and pin-sharp definition, others for imaginative treatment of lighting and composition. Thus the director and camera-man go carefully through the script together and discuss it scene by scene.

Model of the Jodrell Bank radio-telescope used in making "Mirror in the Sky." The purpose of the documentary film is to enlighten or interpret, and models or animated diagrams often add clarity to a narrative or explanation. Such aids as colour may also be required.

Preparing to shoot a laboratory scene for "A Vitamin Emerges." The documentary film maker seldom employs professional players or uses artificial sets. He must therefore learn to work in natural surroundings and to deal with people inexperienced in film making—particularly sponsors.

The question of animated diagrams and models is no less important. An animated diagram is always an easy way out of a difficulty, but a director who is intent on a lively and interesting presentation of his subject will first consider the alternatives. Three-dimensional models, sometimes combined with special photographic effects, are often much more impressive and telling than two-dimensional drawings, but may be troublesome to construct, so that one has to consider the pros and cons in each case. After deciding on the technique, the diagrams or models have to be worked out in detail, designed and ordered. Their shooting takes time, experiments may have to be made, and the necessary discussions with the artists should therefore take place as early as possible.

It is not possible, however, to discuss all the technicalities of shooting, but looking at the many components which go into film-making in the form of personnel, techniques and organisation, it is clear that there are plenty of problems even in a modest production. The amazing thing is not that there are so many problems, but that they are usually resolved without too much heartbreak and within the scheduled time. The secret of successful shooting lies in adequate preparation; that is the main lesson which every film-maker has to learn.

Editing sometimes begins while the film is still being shot, but in factual film work it will more usually follow the shooting. Editing brings its own problems which are mainly of a technical and aesthetic nature. The editing work consists not merely of splicing the various scenes together; it is an intricate art and can make all the difference to the final appearance of the film. The editing includes, of course, the building-up of the sound track with its recording sessions, the laying of, maybe, three or four tracks, the pre-dubbing and dubbing, the optical work, the titling and finishing of the film. The editing period is probably the most interesting one because it is here that the first results of all the labour (script-work not least) fall into shape, until eventually the final film emerges in all its glory. If, that is, there is any glory.

For one final problem remains, and that is the first showing of the cutting copy to the sponsor. Although hardened by years of experience, it is still with the same old sinking feeling that the producer and director of the film look at the sponsorial "jury" (usually poker-faced) as it watches the film. Will the film be acquitted or found guilty ? It is seldom as straightforward as that. In the ensuing discussion it usually becomes clear that the film has passed muster, but that it is found wanting as regards this or that detail. The specialist advisers may now find chronological errors or technical inconsistencies in the story which had not been apparent in the script; the publicity manager may think that the description of the sponsoring firm's achievements in scientific research could have been given more punch; and the film officer may detect some wrong wording in the commentary. As a result, additional scenes may have to be shot, whole sequences re-shuffled and part of the commentary recorded again. But sooner or later (probably later) final agreement is reached, and the first show copy is handed to a sponsor who, if the collaboration of the two parties has been run on a basis of mutual understanding and sympathy, may be heard to say that the result of his expenditure is adequate, or perhaps even a bit more than adequate, to the purpose he has in mind.

* * *

ENCOURAGING CRAFTSMEN

At the Handicrafts and Trade Fair to be held at Munich, the winners of the Federal competition for young craftsmen will receive their awards. At a time when, partly as a result of fixed working hours, industry appeals strongly to young people, additional incentives are necessary to attract them to arts and crafts, and to make them realise the valuable assets that are attached to a craftsman's training. Arts and crafts allow the apprentice a high measure of independence and responsibility, and even though every apprentice may not become an entirely independent master, yet his dependence will never be as great as in industry. A broad basis of training in craftsmanship also tends to develop a well-trained and therefore versatile expert. One of the regulations for the competition prescribes that the "gesellenstüch," which is the piece of work submitted by the apprentice as part of his qualifications as a craftsman must, on principle, be made, or at least assembled, in a work-shop other than the one with which he is familiar, thereby training the young men to adapt themselves to strange surroundings. Another rule is that the work must be done in 12 days or 100 hours.

Although many people consider that with the coming of mass production, the era of craftsmanship is rapidly passing, this is only true to a limited extent. The craftsman is still required, but it is the craft itself that is changing. There is still plenty of scope for the man who can turn his hand to do fine work, even though he may not receive immediately a reward comparable to that obtaining to someone on piecework. The satisfaction that goes with the knowledge of a piece of work well done is a very real thing, although it has often been made a source of ridicule. The craftsman still plays a very important part in much of the final work for machine tools. A large percentage of the finish on these is still a matter of hand work, and of consequent pride. It is therefore interesting to note that the encouragement of the craftsman still forms a considerable item in the German economy.

* * *

COMPANY HISTORY

There must be many firms who, when they reach their centenaries or their less or more ambitious anniversaries, sigh with regrets for their forebears who have not had the sense to preserve the old letters, ledgers and other precious papers that go to the compilation of a domestic history. Mr. R. L. Collison of the Westminster Public Libraries has much experience of the frustrated historian using his files and about a year ago he suggested to Aslib (formerly the Association of Scientific Libraries and Information Bureaux) that it might be a good thing to discuss this question of the preservation of business records. An interesting meeting accordingly took place on March 27 under the sponsorship of Aslib and with the co-operation of the various bodies interested in archive preservation.

Four papers were presented and the subsequent discussion showed a great awareness of the need for preservation. It also showed a great awareness of the difficulties attendant on such a need. Questions of space, discrimination in the choice of material preserved, whether for domestic or a wider requirement, were all discussed. The morning's papers, under the chairmanship of Sir Raymond Streat, the retiring President of Aslib, were by Mr. H. R. Mathys of Courtaulds Limited (The Records Requirements of Industry) and by Mr. R. C. Jarvis of the Council of the Society of Archivists (Records and the Archivist). The afternoon session, under the chairmanship of Mr. S. H. Twining of the tea firm of that name, included a paper by Professor R. S. Sayers, of the Business Archives Council, on "The Work of the Business Archives Council," and Professor J. Simmons of University College, Leicester, on "Business Records in Historical Research."

Letters to the Editor

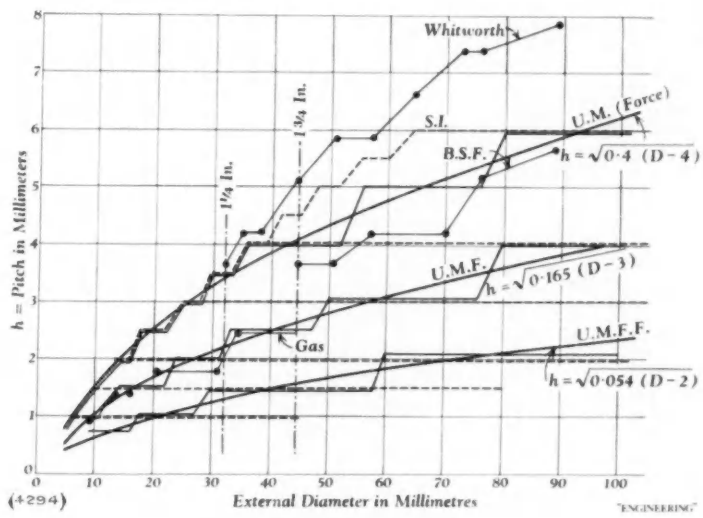
STANDARDISING SCREW THREADS

SIR, As the international congress of the European standardisation offices will take place in Lisbon at the end of April, I would suggest bringing to the notice of its members, through the medium of ENGINEERING, the following ideas on the international standardisation of screw threads.

Coarse Threads.—It is proved:

1. That the Whitworth and S.I. (Système International) threads are unnecessarily coarse above 1½ in. (39 mm.).
2. That the "bumps" at 2½ in. in the new UN (unified) threads and at 64 mm. S.I. are not logical; indeed, fatigue tests on 64 mm. bolts have shown that the 4 mm. pitch gives only 2·3 per cent. less strength than the official 6 mm. pitch; while, on static tests, the 4 mm. pitch gave about 12 per cent. more strength than the 6 mm. pitch.
3. That the fatigue strength, for screws and bolts of 90 mm. diameter, is better with a pitch of 6 mm. than with pitches of either 8 or 4 mm.

In other words, both the Whitworth and the UN threads, above 1½ in., could advantageously be replaced by the B.S.F. (British Standard Fine) or similar pitches, as is shown in the accompanying diameter-to-pitch ratio graph.



Ratio of diameter to pitch.

These facts enable us to trace an ideally parabolic curve giving the maximum pitch for each diameter with the formula $h = \sqrt{0{\cdot}4\,(D-4)}$, where D is the nominal diameter and h is the pitch.

On these coarse U.M. (unified metric) threads, the strength of the thread is equal to the strength of the core. This series can be considered as the one with the coarsest pitch necessary for screws and bolts used in the assembling of mechanical parts. On smaller diameters, the pitch is similar to that of the S.I. and Whitworth threads, while, for larger diameters, it would be more like that of the B.S.F. threads.

This coarse U.M. series with Washington profile offers the following advantages:

1. Better resistance to fatigue.
2. Easier rolling and taping.
3. It corrects the unpleasant "bump" at 64 mm.
4. It avoids the illogical condition of a single pitch of 6 mm. for all diameters above 64 mm.
5. It gives the optimum pitch for large diameters.
6. It determines the coarsest pitches that are necessary and adequate for mechanical industry, and unifies the existing coarse and medium pitch series.
7. It avoids the seizing which is often encountered with nuts of very large diameters, having a pitch of only 6 mm. or ¼ in.

Fine Threads.—It is now easy to derive a finer thread series from the coarse one described above. Two series are recommended:

First, the U.M.F. (unified metric fine) series, corresponding to the formula $h = \sqrt{0{\cdot}165\,(D-3)}$, in which the pitch is about two-thirds that of the U.M. This series would come very close to the B.S.P. pipe thread and could be used for hollow parts, such as tubes, for fixing roller bearings, or for cams on shafts.

Secondly, the U.M.F.F. (unified metric very fine) series, corresponding to the formula $h = \sqrt{0{\cdot}054\,(D-2)}$; the pitch being about two-fifths of the corresponding U.M. pitch. This series would be suitable for optical instruments and similar applications, The diameters of these fine threads need not necessarily correspond to those of the coarse U.M. series. Further, the diameters should be determined by the standardisation offices, in agreement with the users. It is most desirable that a decision on this series should be reached, for they are urgently needed in industry.

The trend to combine inch and millimetre threads in one international standard is futile for practical reasons. Therefore, the following recommendations are made:

1. To accept the coexistence of the inch and millimetre threads for the time being.
2. To improve the present millimetre threads in certain aspects, as explained above.
3. To adopt the Washington profile for these millimetre threads.
4. To change the 24 mm. diameter to 25 mm. and the 27 mm. diameter to 28 mm. This procedure would offer the following advantages by way of compromise between the metric and the inch threads:
   - (*a*) The transposition of one thread for another on drawings would be greatly facilitated (such as from Whitworth to S.I.). (For further details see my article in the *Revue Générale de Mécanique*, August, 1955.)
   - (*b*) Clearance holes of the same diameter would be applicable to both systems.
   - (*c*) The same stocks of rods could be used both for inch and metric bolts.

Yours faithfully,
H. ERNST.

3 Avenue des Chênes,
Le Chesnay (S. et O.),
France.
March 27, 1957.

★ ★ ★

THE BLANKET OF LITERATURE

SIR, Mr. Eco Moulijn, in his letter on "An Engineer's Card Index," published in your issue of March 29, makes a brave attempt to solve the question of who is to index. He confines his comments to "engineering," but let him take "science" as his field and he will appreciate the significance of Mr. R. Silvester's remarks (ENGINEERING, January 11, page 38.) The fact of the matter is that we are, gradually, being suffocated by a blanket of literature. The Archbishop of Canterbury put it in a different way recently, when he said "The world is full of people suffering from acute indigestion, unable to digest the knowledge given them."

Some means will have to be found, one day, to curb the outpourings of the research establishments, the technical schools, and the universities. Otherwise, the printed word will cease to have any significance. As it is, many of the writers have ceased to be readers. Their digestion is so poor that they have to be fed with essences of abstract and digest. They cannot cope with the red-blooded meat of a full report.

Yours faithfully,
F. H. SMITH,
Librarian.

The Royal Aeronautical Society,
4 Hamilton-place,
London, W.1.
April 2, 1957.

★ ★ ★

RELAXATION METHODS

From Sir Richard V. Southwell, F.R.S.

SIR, It is with great reluctance, after his very generous treatment of my latest book (*Relaxation Methods in Theoretical Physics, vol. II*, ENGINEERING, March 22, page 370), that I write to indicate one error of fact made by your reviewer; but my aim in writing the book was to show to engineers the problems they confront that have been successfully treated by "relaxation methods," and the statement (in the last paragraph but one of his review) that "no typical example has been worked out" could, I feel, discourage a structural engineer who thinks of using these methods on a problem involving large deflections. In fact, four of my examples (LVII to LX) are concerned with "von Kármán's equations," and, for all four, solutions are presented, as usual, in contour-diagrams: examples LVII and LVIII relate to static problems, and are solved in Figs. 194 to 197; while examples LIX and LX relate to "well-developed buckling," and are solved in Figs. 199 to 202. (Mr. J. R. Green and I, when we worked together in 1943, knew no other cases of which "exact" solutions were available for comparision.)

I suspect that your reviewer was misled by my assertion (on page 465 of my book) that "the techniques are too intricate to be summarised briefly, . . ." I had hoped that the résumé of chapter XIII would imply that full descriptions had been given in the original paper, which was published in the Royal Society's *Transactions*.

With apologies to your reviewer, and for intruding on your space, I am,

Yours faithfully,
RICHARD V. SOUTHWELL.

The Old House,
Trumpington,
Cambridge.
April 3, 1957.

★ ★ ★

FIRE AT JAGUAR WORKS

SIR, If my interpretation of the letter by Mr. L. R. Chambers, published on page 389 of your issue of March 29, is correct, the main point that he seeks to establish is that fire spreads more rapidly on a smooth bitumen surface that cannot be made to burn until its temperature is raised to 600 deg. F. than on a rough fibreboard surface which can be ignited quite readily at room temperature. He appears to associate this statement, which is hard to assimilate, with a fire at Livonia, in which neither protected metal nor fibreboard was involved. The only correlation between the Jaguar fire and the Livonia fire is that both forms of construction were unsuitable.

The main point of my earlier letter (ENGINEERING, March 15, page 325) was to draw attention

to the fact that protected metal and fibreboard, when incorrectly used, are dangerous, and when correctly used are satisfactory. This is a fact that we recognised many years ago, when we established a method of insulating buildings with the insulating board in contact with the roof sheets and mechanically fastened to them. We also appreciate that, even in this form of construction, if untreated fibreboard is used, there is an unduly high hazard. We therefore developed a method of treating fibreboard so that it has no flame spread. This product is on the market and is specified by us for lined roofs.

Where its fire performance is of small significance, as in the insulation of steel roof decks, we use untreated fibreboard, and are probably the largest individual consumers. Surely our approach to the performance of combustible materials in industrial construction should be to ensure that the method of construction used is that which is suitable, for it is a disservice to any product not to recognise where it is suitable and where it is not.

My firm have given many years to the study of the industrial construction of lightweight roof coverings, and we may legitimately claim to have as wide an experience as anybody in this country. We are more than willing to pass on the results of our work to anyone who can benefit from them.

It is clear that this offer is necessary, because Mr. Chambers is obviously unaware that it is not necessary to line existing buildings below the purlins—indeed, it is not even desirable, since there are sound and economic methods of carrying out this construction with the boards against the roof sheets and mechanically attached to them.

Yours very truly,
C. THAIN,
Managing Director.

Robertson Thain Limited,
Clutha House,
Storey's Gate,
London, S.W.1.
April 5, 1957.

UNMEASURABLE THREAT

Some Comments on the Potential Dangers of Nuclear Radiation

To-day the common man stands confused. Before him the politicians and above his head the scientists argue noisily on the benefits and the dangers of nuclear fission. Facts and figures abound—on roentgens and tolerance levels, background radiation, radioactive fall-out, strontium 90 and bone tumours, mutation and sterility, cancer cures and cancer causes, and a host of other subjects concerned for good or ill with man-made radiation. The measure of disagreement between experts is great, and while controversy rages nuclear weapon tests continue, nuclear power stations spring up and nuclear wastes are dumped into the oceans. The momentum is daily increasing, and the knowledge of consequences, so vital to the human race, is steadily falling behind as nuclear development proceeds.

REASSURANCE

In a speech during the debate on the Bermuda talks last week, the Prime Minister assured the House of Commons that the Government were taking the possible dangers of radiation " very seriously " and were keeping " the closest watch " by means of " regular and up-to-date measurements." He went on to explain that the new man-made sources of radiation, including X-rays and medical treatment, contributed only a fraction to the amount supplied by natural cosmic rays. Estimates made of the addition to external radiation from fall-out resulting from bomb tests show that it is " very small, almost negligible." Asked to comment on the apprehensions expressed by the Government of Japan he replied " I think the apprehensions are really very small. They have no ground for them. They are 4,000 miles away, and they are really not apprehensions they need feel."

No-one appears to have made it clear, however, whether in estimating safe radiation levels (total radiation is presumably divided, in effect, by the surface area of the earth to obtain a mean figure), due consideration is given to the possibility of small wind-borne concentrations of radioactive products reaching inhabited regions. The agreed safe radiation level afforded little protection to the Japanese fishermen who, far from the official danger area in an earlier test, received considerably more than their share of radiation injury. There seems in fact a tendency in many official pronouncements to confuse radiation itself with the radioactive products responsible for radiation. Thus if the products are considered rather than radiation level, the situation appears very different. The variables involved are then seen to be as unmanageable as the meteorologist's. What is more, there is a biological selective factor which ensures that certain of the more harmful products are assimilated by vegetation or crops and hence channelled either directly or through animals to human beings.

Mr. Macmillan condemned the emotional approach to the problems involved. It would be wrong, he said, to underestimate the risks of internal or external radiation, but equally it would be wrong " to excite hysterical or unbalanced fears, and to do so for political purposes would indeed be to plumb the depths of cynicism." Yet it cannot be denied that the possession of nuclear knowledge means power. In the words of one of the leading atomic scientists in the United States, Mr. Charles L. Dunham, " Atomic energy is a new source of power. Those who can master it have in their hands power in the very broadest sense of the word. The power of nuclear weapons and nuclear propelled vessels confers political power. Nuclear power plants confer economic power." It is therefore a great temptation for those concerned with the power of the State to concentrate on the positive aspects of atomic energy, whether for peace or war.

WARNING

The Prime Minister was emphatic that his Government were alive to the dangers to human health that lay in the continued development of nuclear weapons and in the peaceful use of atomic energy. The recent announcement by the Minister of Education of special precautions to be taken to protect students and staff at technical colleges, and of the necessity for the strict control of radioactive materials and waste are evidence that the Government are all out to minimise the risks. They are also a recognition that the risks exist, and that relatively little is yet known about them. It is this lack of precise knowledge about the dangers, and the uncertainty concerning the effectiveness of safety precautions, which is cause for concern. An official of the United States Atomic Energy Commission recently delivered a paper to a symposium on " Radiation Hazards to Mankind " in New York, entitled " Everybody's Business." The warnings contained in this and other papers indicate that the scientists are prepared to recognise that a threat to mankind in fact exists, and that it is everybody's business—not merely that of scientists and politicians.

Much useful information on the effects of radiation on health was published last year by the Medical Research Council in their report on *The Hazards to Man of Nuclear and Allied Radiation*. The Division of Biology and Medicine of the United States Atomic Energy Commission have also made important contributions to public knowledge. The worrying part of such publications are the gaps in knowledge which they reveal. The clearest intimation of this was perhaps given last month by a study group of 20 experts from nine countries which met in Geneva under the auspices of the World Health Organisation. These scientists, who included representatives from this country and the United States, considered that considerable expenditure of money and effort was required urgently to reduce the threat by developments in the use of nuclear energy to the well-being of the next generation and to the orderly development of future generations. They emphasised the need to understand the effects of exposure, since " only in the light of much knowledge can decisions be taken to define more accurately the maximum amount of exposure which may be accepted by individuals and populations without risk of serious harm."

UNCERTAINTY

The two papers read to the symposium on radiation hazards by the director and deputy-director of the Division of Biology and Medicine, United States Atomic Energy Commission, provide some of the most up-to-date information published so far on both the credit and debit sides of atomic energy. The Director, Mr. Charles L. Dunham, speaking on " Atomic Energy, Medicine and Research," warned that the careless use of atomic power " even in strictly peaceful activities, could quickly discredit nuclear energy as a means of social advance." He traced the development of the use of radioactive substances in medicine since Roentgen discovered X-rays in 1895 and Henri Becquerel discovered radioactivity in uranium salts in the following year. The use of radioisotopes in medicine, agriculture and industry was described, and some of the immense potentialities of these materials for the good of man were indicated. Yet Mr. Dunham concluded most emphatically that " no exposure of persons to radiation without at the same time some useful purpose being served for the individual or for the group " should be contemplated. His deputy, Mr. C. W. Shilling, dealt with the threat of radioactive fall-out from bomb explosion.

Mr. Shilling was much more cautious in his answers to the question " is radioactive fall-out dooming the race? " than Mr. Macmillan was in April. " We are searching," he said, " for facts pertaining to fall-out but the problem is most complex and difficult even at best, and when approached emotionally and not scientifically, it becomes all but hopelessly tangled." He does not answer the question but implies that the danger is not so great and that it is worth taking, weighed against other dangers. He argues that the United States must accept the risks of radioactive fall-out not only to study the characteristics of weapons but " to study ways and means of protecting populations from their effects should they be used in warfare."

EVERYONE'S CONCERN

There is nothing in the words of scientists to confirm the Government's bland assertions that atomic bomb tests are safe; in fact, very little to prove that the peaceful use of atomic energy is safe. But the threat lies in the future and extends not to individuals but to mankind. It is therefore remote, and precise knowledge is lacking. But this is no reason to rush ahead and to say, as Lord Mills has said in respect of nuclear power stations, " It is not that there is a risk. It is that people think there is a risk." The scientists at Geneva did not say this, nor did the experts of the A.E.C., nor for that matter have our own nuclear physicists.

But the government of a country so dependent on nuclear energy for defence and industrial expansion as is our own cannot be expected to underline the dangers. It is everyone's concern, and there is no hysteria in stating, as *The Times* did last week, that " the onus is on those who make explosions to satisfy the world at large of their safety."

Weekly Survey

Cover Picture: *Phosphor bronze is the usual material for wormwheels, one of which is shown nearing completion on a hobbing machine. The machinist is making a check on tooth thickness which will give a fair measure of the backlash that will be effective when the gear is in operation.*

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World Economic Progress

The 1956 Statistical Yearbook prepared by the Statistical Office of the United Nations provides a wealth of interesting statistics on world economic progress over the last two decades. The latest figures relate to the year 1955 when world economic activity (excluding the U.S.S.R., Eastern Europe and China) reached a record level with total output from factories and mines about twice as high as in any pre-war year. Moreover, the rate of increase of output is rising and amounted to 10 per cent. in 1955 compared with 1954: if maintained, this would result in a further doubling of mining and manufacturing output in a little over seven years.

The expansion achieved over the last 20 years represents a marked improvement in the average standard of living since world population (in this case excluding the U.S.S.R. but including China) rose by only 20 per cent. between 1940 and 1955, and by 33 per cent. between 1930 and 1955. In contrast to the industrial expansion the output of the principal agricultural products has increased only slightly faster than population, the 1955 world wheat crop showing an increase of 22 per cent. over the average for the years 1934 to 1938, maize 33 per cent., rice 32 per cent., milk 18 per cent. and meat 26 per cent., while the potato crop was 2 per cent. below the pre-war average. The main reason for this appears to be that in the more highly developed countries of Western Europe, the British Commonwealth and the United States, available supplies of foodstuffs already exceed 3,000 calories per capita per day and this figure is unlikely to increase further. In India, Burma and Ceylon where the figure is below 2,000 calories, increased industrialisation is a prerequisite of ability to expand production or pay for increased imports.

If allowance is made for increasing efficiency of fuel utilisation, energy consumption provides a useful indication of the overall trend of industrialisation. On this basis the most outstanding advances have been made in South America, where total energy consumption increased by 221 per cent. between 1937 and 1955, followed by Africa 161 per cent., Oceania 113 per cent., North America 83 per cent., Asia (excluding U.S.S.R., China and North Korea) 69 per cent., and Western Europe 34 per cent. Although statistics are not complete, the corresponding figure for the U.S.S.R., Eastern Europe and China was about 158 per cent. Nevertheless, in 1955 the United States alone accounted for 40 per cent. of total world consumption of energy, Western Europe for 23 per cent., and the Iron Curtain countries for 22½ per cent. Asia accounted for 5¼ per cent., South America 2 per cent., Africa 1¾ per cent., and Oceania 1¼ per cent. Since Asia (excluding China) accounts for about 40 per cent. of the total world population these figures show that the main problem facing the Free World over the next few years will be assistance in the further industrialisation of Asiatic countries.

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Opposition to European Free Trade

The possibility of the " total destruction " of whole industries in the event of Britain joining the European free trade area was referred to in a letter sent last week to the President of the Board of Trade by the National Union of Manufacturers. The President of the N.U.M., Mr. G. S. Garland, sent a list of 36 industries which have expressed their apprehension and said in a covering letter that the smaller firms and lighter industries were likely to suffer considerably and therefore required the Government's protection. Unless these companies could be told how they would be safeguarded, " the Union must have grave doubts whether it could support the proposals."

This is the first collective opposition to the Government's policy of taking part in a free-trade area. Mr. Garland does not deny that " in the long run and for the country as a whole " such a step might be beneficial, but questions whether it is in the national interest to permit " the grave weakening or total destruction of a number of industries in this country." He argues that the Government ought to take possible steps to ensure that the damage to individuals is minimised, since a substantial re-adjustment of the country's business is clearly envisaged in the proposals.

Such opposition was bound to come, and there is little doubt that it will get stronger. But so far very little concrete study of the implications of taking part in a European free-trade area has been done. The N.U.M. state all the familiar arguments in favour of protection, including considerations of strategic importance. The major point they make is that the small firms, some of them founded during and immediately after the war to reduce the country's dependence on imports, are least able to withstand foreign competition although they constitute a very large part of British industry. This is tantamount to saying that a large part of British industry is unable to compete overseas.

Yet in the years to come the country's prosperity depends above all on increasing its share of export markets. To take away protection will hurt and may destroy some firms but not necessarily those employing the country's scarce resources to best advantage. Many companies, small ones among them, have welcomed the opportunities of freer trade. The N.U.M.'s case is stronger where it places emphasis on the need to ensure a greater equality of opportunity in respect of labour costs, taxation, depreciation allowances and exchange rate.

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Two Electrical Giants

" We are of the opinion," said Lord Chandos at the annual general meeting of Associated Electrical Industries, Limited, " that the electrical industry in the next 10 years will nearly double in size." Looking back over the past 10 years, he points out that in most respects—capital employed, fixed assets, stocks and works in progress—A.E.I. have increased four-fold. The group, which acquired Siemens Brothers and other companies during that period, employed at the end of last year 88,912 people, compared with 50,913 in 1947. Turnover had increased from £36·6 million in that year to £133·19 million in 1956. Despite the setback in profits last year, due to a number of causes likely to prove temporary, Lord Chandos expressed confidence in continued expansion. There has been an " unusually large " influx of orders this year and the production of several new factories will shortly become available.

The other electrical engineering giant whose report was published last week is A.E.G. (Allgemeine Elektricitäts-Gesellschaft) of Berlin. Recovery from the severe losses due to the war was quick and to-day A.E.G. are once again one of the industrial giants of Germany. Total employment rose by 10 per cent. last year, to 51,500, including 7,000 technicians and 3,000 apprentices and trainees. Turnover rose by 20 per cent. to D.M.1,097 million (about £93 million), of which about one-fifth was exported. The considerable emphasis on exports is shown by the fact that they accounted for half the increase in turnover.

Both companies place considerable emphasis on expanding demand and on the need for the allocation of ever higher amounts to research and development. A.E.G. report that " technical progress has continued to multiply " and that the full-scale efforts being made in this direction " will involve considerable expenditure but represent the basic prerequisite for the company's future success." Cash needs have been high, and capital was raised by D.M.110 million to D.M.275 million. As in the case of their British competitors, earnings were affected by " the continuing upward tendency of costs." International competition " remains strong " but there is little in the report to suggest that A.E.G. do not agree with A.E.I. concerning the bright prospects that await the enterprising in the electrical engineering industry.

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Organised Labour in America

The A.F.L.-C.I.O. Collective Bargaining Report issued at the beginning of this year makes very interesting reading at this time. The report states that wage increases were roughly 3 to 5 cents an hour above the 1955 level and that most negotiations included provision for various fringe benefits covering health, welfare, pensions and paid holidays. The really significant developments over the year were firstly an increase in the number of agreements for a year or more, secondly, the inclusion of cost-of-living escalator (sliding scale) clauses in these agreements, and finally the negotiation of supplementary unemployment benefits.

To us in Britain the outstanding feature of these new-style long-period agreements is that they give both sides a chance to concentrate on the job of industrial production. The employers know what their labour cost commitments will be a year or more ahead. The workers know they will get certain " deferred " increases, usually of 5 to 10 cents an hour at specified dates during the year. On top of this the escalator clause takes care of any sudden jump in the cost of living. No bargaining is scheduled under major agreements running right through 1957 for a number of important industries. Motor-car workers are covered by agreements lasting until mid-1958. Agreements made by the International Union of Electrical Workers with the General Electric and Westinghouse Companies run until 1960. The Steelworkers are committed to agreements lasting until 1959. The principal industries in which bargaining is due in 1957 are oil, rubber and men's clothing, in all of which national agreements come up for re-negotiation. In addition, aircraft workers at some plants, including Lockheed and Cessna, and some glass, paper and railways workers are due for new agreements. Most of the shipbuilding industry covering the East and Gulf coast ports is covered by agreements which run throughout the year. But it will be interesting for us here to see what happens to the Pacific Coast shipyards agreement which ends in June. Perhaps the Confederation of Shipbuilding and Engineering Unions could arrange to send a fraternal delegate over as an observer. From the look of this report it would be money well spent.

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Motor Car Symptoms

The report of Vauxhall Motors for 1956 provides additional evidence to show that when trading conditions are difficult, increased taxes and hire purchase restrictions on the home market do not produce an immediate diversion of cars to export. In the words of Mr. G. N. Vansittart, the chairman, and Mr. Philip W. Copelin, managing director, " The new plant and equipment we have installed will, if fully utilised, attain new standards of high productivity and low cost, and we are anxious that customers both at home and abroad should be allowed to benefit from this technological progress. However, if the markets for our products continue to be deliberately depressed by arbitrary restraints of uncertain duration and extreme severity, the

economy cannot be insulated from the effects of those restraints and inevitably, the cost and price of vehicles not only for the home market but also export will have to be increased."

It all sounds obvious, but it is clear British politicians still have no true conception of the importance of the automobile to the industry and commerce of the nation. The increase in the fuel tax at the time of the Suez crisis, maintained long after the crisis has passed, and the continued refusal to build a modern road system are examples. Equally revealing have been the statements urging motorists deprived of the use of their cars by rationing to use public transport —but outside the rush hours; evidence that in the official mind, possession of a car is still equated with wealth and leisure.

Vauxhall sales in 1956 were 123,643 vehicles (including about 65,000 cars) against 142,149 in 1955. Exports were 64,051 against 76,071 in the previous year, but deliveries to Canada increased by 70 per cent. Home sales at 59,592 vehicles were down 10 per cent. on the year, whereas export sales declined by 16 per cent.

Salaries and wages rose by 12½ per cent., while net profits dropped by 40 per cent. Materials and services now absorb 67·3 per cent. of total income, and salaries and wages, plus employee benefits, take 19·5 per cent. Employee benefits, including pensions, insurances, holiday pay and profit sharing, add nearly 17 per cent. to the wage bill. Net profits were £3·9 millions against £6·5 millions in 1955, representing 5·5 per cent. of turnover. Tax provision on profits was £2·4 millions, and in addition, the company collected over £10 millions in purchase tax from its customers, on behalf of the Government. These figures are perhaps symptomatic; the application of restraints may have additional consequences which are both unforeseen and undesirable.

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New Dollar Drive in Cars

Grounds for cautious optimism in the motor vehicle industry continue to appear. While more factories are once again working full time and re-engaging staff declared redundant last year, exports of passenger cars and chassis in February showed an appreciable rise over the corresponding figure for last year; 28,400 vehicles were exported compared with 26,040 in February, 1956. This is the first time for over twelve months that this has occurred.

While these figures by themselves give little cause for great optimism—the figures for January were stilll appreciably below last year's—other indications are that there may be a considerable expansion of exports this year. Both South Africa and New Zealand have announced relaxations of import controls, the latter at the request of the United Kingdom Government. Neither of these relaxations is of very great quantitative importance, and motor vehicles have been excluded from the latest Australian import concessions pending completion of a review of the Dominions' motor industry.

It is to the American market that many manufacturers are looking for expansion. While American manufacturers are tending to produce cars of increasing size, a growing demand is reported for European sized cars.

Hitherto, sports cars have met with the greatest success in the American market, but the British Ford Motor Company announced recently that they are embarking on a new marketing programme aimed at developing sales in America to over 20,000 units a year. It is reported that the Anglia and Prefect and their estate car versions are now well established as all-purpose light cars, and in some states are meeting the very sizeable demand for "second" cars. It is predicted by United States car dealers that imported car sales will reach a record level in 1957, and there is no reason why British manufacturers should not benefit appreciably from this. Fords report that even the higher priced Consuls, Zephyrs and Zodiacs are selling well, although these compete more directly with American cars.

While there must be some irony for the austerity ridden British in supplying Americans with "second" or even "third" cars, these crumbs from the master's table will be more than welcome. Perhaps the dollar grin may appear in British motor vehicles in a new sense.

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Cheerful Outlook

A number of companies whose annual statements were published recently share the Government's confidence in the expansion of output and more particularly in the good export prospects forecast in the Economic Survey for 1957. They are a good sample—Asquith for machine tools; British Oxygen for industrial gases, welding plant and electrodes; British Tabulating Machines for office mechanisation; Crofts Engineers for geared electric motors; Negretti and Zambra for instruments; de Havilland for aircraft; Delta Metal for non-ferrous metals, etc. All show increased profits and in some cases performance is outstanding.

British Oxygen are perhaps the most broadly based and should therefore reflect the position of engineering as a whole. The Chairman's remarks that a record of "vigour, enterprise and progress" enables the company "to look forward with confidence, as we do" suggest no anticipation of an engineering slump. Mr. Robert W. Asquith, chairman of Asquith Machine Tool Corporation, reported a rise of nearly £40,000 in net profits, to £334,000 and goes on to express great confidence that "even further expansion" must be undertaken in the years ahead, if only to lighten the country's dependence on imported machines. Like most of his colleagues in expanding sectors of specialised plant production, Mr. Asquith finds securing the necessary capital out of taxed profits and his requirements of skilled labour very difficult. B.T.M. suffer from similar problems of shortages, but consider the outlook "an encouraging one."

De Havilland reaped high rewards from their Canadian enterprise, although the United Kingdom side of the business is not expected to do really well until the new series of Comets comes into service. Trading profits rose by 47 per cent. to £3·8 million. Delta Metal, who now own Manvill Booth and Elkingtons, are one of the largest suppliers of non-ferrous metal in all forms. Their increased profits suggest that the demand for their products was well maintained. A similar picture emerges from the preliminary figures of Crofts Engineers whose trading profits for the year ending December 31 rose by 17 per cent. to £1·2 million. Negretti and Zambra, who supply instruments to a very wide field of industry, record an increase in turnover and profits which Mr. P. A. Negretti, their chairman, describes as "very satisfactory."

There is little doubt that for most of these companies the past few months have been less good than the period included in their reports. But no-where is there any feeling of despondency.

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Air-Cooled Diesels

The announcement last week that an air-cooled 8 litre Diesel engine for road vehicles is in course of development at the works of the Midland Motor Omnibus Company, Limited, is a reminder of the increased interest which has been taken in this type of Diesel engine recently. The trend towards air-cooling is fairly well established. The big problem is to get a new engine established which is impressive enough at the development stage to make it worthwhile to design equipment to suit it and to impress potential buyers with the certainty of a good after-sales service. Even well known companies, where good service in spare parts is assured, have found that it has taken well over 5 years to establish an air-cooled type.

The pace in the development of the air-cooled Diesel has been set of recent years by Klöckner-Humboldt-Deutz A.G. of Cologne. This company which has established a number of models with cylinders ranging from 1 to 12 now claims that its air-cooled engine is as popular as the corresponding water-cooled types. In this country 3 or 4 manufacturers have developed a useful range of industrial air-cooled engines and ranges are likely to be extended in the next few years. The advantages in lightness and operating efficiency in extreme temperatures where there is no water jacket are long-term advantages which must accrue to the air-cooled Diesel. Meanwhile its popularity is hindered not only by the natural conservatism of potential buyers but also by the sheer expansion of the Diesel market. Ignoring variations in the demand for Diesel engines because of the trade cycle, there has been and continues to be a major expansion in the range of engines offered, especially between 100 and 300 h.p., as well as an increase in the number of engine units produced. Under such circumstances the industry is much pre-occupied in building up an after-sales service in established models, a service which left much to be desired a few years ago both in the home and export market. The advantages of the air-cooled Diesel, however, must be exploited as quickly as possibly if for no other reason than that the European Common Market may be just around the corner.

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Main Line Electrification

Railway main line electrification reached a more concrete stage with the announcement on March 29 that the British Transport Commission have placed contracts with four companies for electric locomotives to a value of about £6 million. The contracts are for the supply of 60 complete main line locomotives and 40 electric equipments for locomotives to be built in British Railways workshops. Deliveries of the 100 locomotives are expected to start late in 1958 and to be completed during 1960. Sir Brian Robertson stated early in March that 20 electric main line locomotives were expected to be delivered during 1958. The contracts for complete locomotives have been placed with four companies, British Thomson-Houston, English Electric, Metropolitan-Vickers and General Electric. General Electric's locomotives have been developed in close co-operation with the North British Locomotive Company, who will build the mechanical parts. The electric equipments have been ordered from British Thomson-Houston.

The locomotives ordered are of two mixed-traffic types. One is intended to haul express passenger trains of up to 475 tons at speeds of up to 100 m.p.h., or, alternatively, to haul mineral trains of up to 950 tons at 55 m.p.h.; the other is intended to have a maximum speed of 80 m.p.h. but to be capable of hauling mineral trains of up to 1,250 tons at 55 m.p.h. Both will be of 3,300 h.p. continuous rating.

These locomotives are intended in the first instance for use on the Crewe-Manchester and Crewe-Liverpool lines, the first stage of the major electrification programme for the Midland region, which is to be extended ultimately to Euston. The contracts for the track electrification over these sections and the Colchester-Clacton section of the Eastern Region were placed last year and work is in progress.

The dovetailing of the track electrification and locomotive building programme calls for careful co-ordination. The rate of electrification is planned to build up to a peak in 1962, when it is estimated that 1,000 miles a year of electrified single track will need to be commissioned, and that at least 200 electric locomotives and 900 electric multiple units a year will be placed in service. The first sections of electrified track are scheduled for completion in mid-1958, by which time the first of the main line Diesel locomotives and most of the first batch of 2,400 Diesel multiple units should be in service. Thus, in eighteen months' time the new face of British Railways will begin to emerge.

STEEL PLATE: THE THREAT OF SCARCITY

By H. J. Novy

Few threats are as basic to this country's industrial growth as the shortage of steel plate. And few shortages are as protracted. Despite assurances to the contrary British industry is likely to be as short of plate and other heavy rolled products in five years' time as it is now. This will retard the already dreadfully belated re-equipment of our railways, undermine the long-awaited expansion of our shipbuilding industry, deny us the wonderful opportunity to play a major part in world pipeline construction. It will be an obstacle to the rapid implementation of the atomic energy programme, to the building up of adequate oil storage capacity and to the necessary expansion of storage for efficient distribution of petroleum products. It will interfere, as it is doing now, with the production of road transport vehicles, locomotives, oil field equipment, steel works plant and a host of other heavy engineering products, for which there is a large and growing export demand. Finally, it will make the United Kingdom a net importer of heavy plate with all the undesirable consequences of such a position.

The steel industry vigorously reject this view. On the basis of information supplied to them by the principal users of plate, including the oil and shipbuilding industries and structural engineering, they say that the 4 million ton capacity planned for 1962 should more than meet industry's demands and leave us with a surplus for export.

WRONG FORECASTS OF DEMAND

The Steel Board say that by 1962 there will be plate galore. Our inquiries suggest that this will not be so. In the Board's *Development of the Iron and Steel Industry*, 1953 *to* 1958, published in February, 1955, it is stated that the total capacity for plate in 1958 " is expected to be about 2·7 million tons, and it is believed this will be quantitatively adequate to meet demands." In this they acted on the best advice they could get from the Government on the nation's industrial expansion and from using industries. Both the shipbuilding and oil industries—incredible as it may seem—predicted a fall in their total requirements.

Only 18 months later, in July, 1956, the Board have substantially revised their views. *The Annual Report of the Year* 1955 comments that " it became apparent during the later part of the year under review that demand for plate is likely to be greater than had been expected when the development report was written. " It is now clear that the plate problem is one of quantity as well as of quality and the Board are pressing the industry to provide a further increase in plate production." They succeeded in this up to a point, and the various expansion schemes at the works of Colville's, Patent Shaft and Axletree, Appleby-Frodingham, Consett Ironworks, Stewarts and Lloyds, and South Durham Steel and Iron Company are commented upon further on. The main points about the plans are (*a*) that they came too late, (*b*) that they are due to force of circumstance and not the result of forward planning, and (*c*) that they are no more closely related to long-term demand than were the plans drawn up in 1955. There would appear to be an almost complete absence of demand forecasting in the industry or, if the facts are available and the trends plotted, a stubborn refusal to take the risks involved in acting on any kind of forecast. To some extent this may be due to the present uncertainty of technical developments in steel making, such as the use of oxygen-blown converters, and of continuous casting techniques. This could make new plant of orthodox design obsolete very quickly. On the other hand, the present policy of wait and see what foreign steelmakers are doing could be interpreted as yet another sympton of the fear of risk taking.

PERFORMANCE SO FAR

The production of heavy and medium plate (3 mm. thick and over) totalled 1·36 million tons in 1938; in 1953 this had risen to 2·48 million tons, and in 1956 to 2·64 million. This represents an increase in production of some 93 per cent., compared with one of nearly 110 per cent. for crude steel. It is equivalent, however, to a lesser increase in specialised heavy and medium plate capacity, for substantial quantities—estimated at 300,000 tons—were rolled on continuous strip mills, taking advantage of the fall in demand for motor-car sheet during the year. There will be less scope for similar relief during the current year if the motor vehicle industry recovers as expected. Moreover, to quote the Steel Board, continuous mills can produce large quantities of plate " only by leaving their expensive sheet finishing equipment partially underloaded." On the other hand, provision is made in modern strip mills for excess hot rolling capacity for the production of plate, which is a good source of profits, and there will doubtless be some increase from that source. In 1955, when the demand for sheet from the motor industry was at its peak, supplies of plate were sharply reduced. A coincidental high overseas demand led to a sharp rise in exports.

Deliveries to the home market, which had risen slightly between 1953 and 1954, fell in 1955 when they were 5 per cent. lower than in 1953. The sizeable increase in home deliveries last year was due mainly to output from the strip mills. The fact to bear in mind is that plate deliveries have not kept up with the index of production in the metal and metal using industries, which rose by 24 per cent. between 1951 and 1955. In the last quarter of 1956 there was a sharp increase in stocks, of almost 60,000 tons, and imports are currently being reduced below last year's level of 200,000 tons. There is a danger, however, that the recovery of demand for sheet now taking place will reduce supplies of plate and imports may therefore have to be increased again. This could be considerably above 200,000 tons a year if home users are not to be starved of supplies before the industry's expansion plans are completed.

PATTERN OF CONSUMPTION

Deliveries of plate to the principal consuming industries are listed in the table below. The largest consumers by far are shipbuilding and constructional engineering. In 1956 shipbuilders took 23 per cent. of total home deliveries of plate and constructional engineers 14 per cent. In addition, those two industries doubtless received substantial supplies from stockholders who were allocated just over 13 per cent. of total deliveries. Other important users were builders of rolling stock, of road vehicles, and boiler makers. Information available on demand suggests that this pattern will not alter very substantially during the next five years except for the emergence of nuclear engineering as a major consumer towards the end of that period. The major difference will be in the scale of demand.

SHIPBUILDING

Shipbuilders say that, given all the plate they need, they could increase their output by one-sixth. There is little doubt that if they do in fact succeed in quickening the rate at which ships are built in British yards, they will require substantially more plate and heavy sections. Order books are said to be equivalent to four full years' output at the present rate, i.e., about 1·5 million tons of ships completed per annum. The amount of plate required per gross ton of shipping is tending to fall slightly, perhaps by 1 or 2 per cent. a year. Being due to the adoption of butt welding and prefabrication techniques, the use of corrugated bulkheads and other developments which are gradually taking place, this rate of saving is unlikely to be maintained. Moreover, the tendency for more and more yard capacity to be taken up by tanker tonnage, which requires more steel per gross ton than dry cargo, tends to offset this saving. Assuming, therefore, that the plate requirement does not fall below 0·38 tons per gross ton of shipping, the shipbuilding industry's present order book of about 6 million tons would need some 2·3 million tons of plate. If this building in fact takes four years to do, the annual consumption will not greatly exceed the 1956 level of 550,000 tons. If, on the other hand, the shipyards' output rises by 10 per cent. per annum through expansion schemes and the adoption of new methods of building, they will only need just over three years to work through the present order book, and plate requirements will average some 750,000 tons a year, or 45 per cent. more than current supplies.

If the steel industry is unable to meet this demand, which is more likely to rise than fall over the next decade, it could have disastrous consequences. One would be to check the shipbuilding industry in a much overdue expansion and modernisation drive and cause it to lose further to Japanese, German and United States competitors; another could be to hasten the use of substitute materials for hull construction. Reviewing his company's prospects, Sir Andrew McCance, chairman and managing director of Colvilles, mentioned that " demand for steel continues strong," particularly for heavy rolled products. He talked of output being taken up " for a large part of the next financial year." In this context it would have been more apposite had he taken a five-year view. He and his colleagues in other large plate producing companies could with every justification take shipbuilders to task for not standardising their

STEEL PLATE AND HEAVY ROLLED PRODUCTS: NET DELIVERIES TO CONSUMING INDUSTRIES, MERCHANTS AND EXPORTS: 1951, 1955 AND 1956

(THOUSANDS OF TONS)

—	Steel plate 3 mm. thick and over			Other heavy rolled products		
	1951	1955	1956	1951	1955	1956
Coal mining	12·9	16·8	18·3	68·8	89·5	83·6
Iron and steel	44·3	43·2	60·3	29·8	25·1	33·2
Shipbuilding	501·9	506·8	550·1	148·0	130·3	159·2
Marine engineering	46·7	41·1	51·9	8·1	6·1	7·4
Boilers and boilerhouse plant	64·4	59·9	69·6	18·5	20·8	18·2
Constructional engineering	268·2	271·0	329·7	485·0	586·6	597·4
Electrical machinery and apparatus	60·0	64·6	64·1	11·8	9·6	10·6
Motor vehicles, cycles and aircraft	128·3	173·2	153·8	16·9	16·3	12·7
Rolling stock	127·9	169·6	174·4	110·6	169·1	194·7
Metal furniture	34·5	38·7	39·9	8·6	10·6	9·0
Building and contracting	7·5	7·4	8·4	41·9	45·1	41·1
Other industries	266·0	290·4	320·2	151·3	140·5	152·9
Stockholding merchants	233·2	317·3	313·8	268·9	343·7	286·6
Unallocated imports	—	59·8	194·2	—	66·9	187·0
Total	1,795·8	2,059·8	2,348·7	1,368·2	1,660·2	1,793·6
Exports by producers	231·2	236·8	500·4	134·5	156·2	153·1
Grand Total	2,027·0	2,296·6	2,849·1	1,502·7	1,816·4	1,946·7

orders to a much greater extent. Plate throughput could doubtless be increased, and probably by a large margin, if less variety was present—if, for example, shipbuilders did their own cutting to size. In this respect steel producers have something to learn from that section of engineering accustomed to producing components in large quantities. Heavy price differentials on non-standard specifications can quickly restore order. This, as well as more capacity, is urgently required.

LAND TRANSPORT AND PIPELINES

The importance of road transport vehicles and rolling stock is clearly shown in the table. Between them in 1956 these industries consumed over 328,000 tons of plate 13 mm. thick and over, or nearly 14 per cent. of total deliveries to home consumers. The long-term prospects of heavy road transport were discussed in a recent article (ENGINEERING, March 29, page 408, 1957). They are very good, both at home and overseas. The rolling-stock requirements of British Railways are said to be currently at their peak. This could be so, for their investment policy is subjected to political considerations. By no stretch of the imagination, however, can it be suggested that this capital-starved industry will be fitted out with all the wagons and locomotives it requires by 1960.

Pipelines are rapidly becoming a normal method of transporting liquids over land. The projected additional pipeline in the Middle East, and the need for an extensive network in this country for distributing oil and for transport from terminal to refinery will mean a vast increase in the demand for welded tube. Figures published by Stewarts and Lloyds show that their steel-tube output (of all types) has nearly doubled since 1946. The following comments by their chairman, Mr. A. G. Stewart, are explicit enough. "Demand from the oil industry, our deliveries to which in 1956 increased by 16 per cent. over the figures for the previous year, continues at a very high level and still exceeds our capacity to supply." The considerable expansion planned by South Durham is designed primarily to provide plate for their new steel-pipe plant. A rate of increase of 20 per cent. per annum in demand from this source is to be expected during the next few years.

PETROLEUM AND NUCLEAR FUELS

The sudden closure of the Suez Canal revealed a dangerous shortage of storage capacity in this country, both at refineries and at distribution points. It has been suggested that facilities for storage should be at least doubled. Moreover, the increasing momentum of oil-fired central heating for houses and flats brings in its wake a need for oil tanks. No one has yet worked out the implications of these programmes, to which should be added new refinery construction and expansion, in terms of steel plate. A large modern refinery may require 200,000 tons of steel, a seaboard terminal for receiving and distributing supplies 10,000 to 20,000 tons—much of it in the form of plate. The steel industry, on information supplied by the oil companies, confidently expected this demand to fall off after 1955; not only did it fail to do so but it is increasing substantially and rapidly.

The atomic energy programme is still very much on paper. But £919 million is scheduled for expenditure by 1965, involving 19 nuclear power stations. Although the total steel requirements will not, in fact, be much greater than those of equivalent coal-fired stations, the type and quality will differ, and place a great additional strain on the capacity of the steel-plate industry. Some 40,000 tons of 3 to 4 in. thick high-quality steel plate is required for each high-pressure vessel built to enclose the reactor furnaces. This means some ¾ million tons of this type of plate in seven years. In addition there will be the plate required for boiler construction, which in 1956 consumed nearly 70,000 tons. This proposed expansion of electricity generation by atomic energy will without doubt place a heavy burden on the steel industry's plate rolling resources. Yet so far nothing has been said concerning new capacity for the purpose; only that "top priority" would be accorded in order to meet the requirements of the programme.

THE SCALE OF THE EXPANSION

The industry's expansion plans were summarised by Sir Andrew McCance speaking in his capacity as president of the British Iron and Steel Federation, at the annual meeting of the Federation last month. To supply the needs of the plate using industries "six modern 4 high plate mills should come into production between now and 1962, raising the annual output of plates by more than 1 million tons above the present figure." Output in 1956 was approximately 2·6 million tons; in 1962 it will presumably be approximately 4 million tons. The rate of expansion this represents amounts to something under 10 per cent. per annum average increase.

Sir Andrew comments that when the plans for development are complete, "we are confident that there will be enough capacity to make all the finished steel likely to be required in 1962." It would be interesting to hear the views of the rest of the industry's leaders, and of the Steel Board themselves. To say as the Board did that they are "pressing the industry" implies at best a lukewarm approach to expansion and at worst a resistance to it on the part of the leading firms.

If persuasion does not prove successful the only remedy open to the Board is action under clause 5 section 3 of the Iron and Steel Act, which enables the Board to put down plant if the industry reject the Board's advice in matters of capacity expansion. But the Board cannot themselves escape a measure of blame for the present situation. They have never shown very firm resolve to set up the additional capacity to provide some "elbow room" for the industry, on the grounds stated in their two development reports "that it is desirable to have a margin of capacity to meet the possibility of greater demand."

PRIVATE ENTERPRISE

Much remains to be done to provide the United Kingdom with adequate steel support for continued industrial expansion. The latest plate schemes suggest that the steel industry is endeavouring to supply plate of the right quality.

Modern 4 high plate mills meet the need for greater precision in rolling and provide good flat plate more economical to use than that produced by the older mills. The Board's report for 1956 (published in July last year) mentions the two schemes at the Appleby Frodingham Steel Company branch of the United Steel Companies and one at the Patent Shaft and Axletree Company, Limited, which together will yield additional capacity of some 150,000 tons of plate. Appleby-Frodingham are to replace a 10 ft. finishing stand of the 12 ft. wide plate mill by a 4 high 12 ft. stand.

Patent Shaft and Axletree's scheme comprises the modernisation of the melting shop, two additional 75 ton furnaces, a new slabbing and blooming mill and a 4 high mill. Other schemes were subsequently announced by Colvilles, Stewarts and Lloyds and South Durham Iron and Steel Company.

The South Durham scheme, which is the largest in the industry, includes a new 4 high 12 ft. 6in. mill and full supporting plant at Greatham, near West Hartlepool, which, when completed in 1962, will provide some 600,000 tons of plate a year and will raise the company's capacity beyond the million ton mark. Another 2,500 to 3,000 workers will be needed, and some £43 million spent on the new works, or £71 per ton of new plate capacity. This, however, is a low figure conditioned by the fact that the South Durham scheme is utilising a substantial proportion of existing plant. The industry consider that at present prices about £100 of investment is required per ton of modern integrated plate mill capacity. Yet the South Durham scheme is designed to meet the vast demand developing for welded oil pipe, which has suddenly and completely taken over capacity. Other companies including Colvilles, Stewarts and Lloyds and Consett Ironworks, are modernising their rolling mills and ancillary plant. The increase of 10½ per cent. in the price of heavy plate will help to create the right atmosphere for expansion. So far, however, there is no sign that the industry has tackled the plate problem other than by chasing some way behind demand. Sir Percy Mills, the new Minister of Power, has a big job to do if he is to be successful in removing the threat of scarcity from the users of heavy plate.

CHANGES IN BULK ELECTRICITY SUPPLY CHARGES

Two important changes have been made in the tariff under which electricity is supplied in bulk by the Central Electricity Authority to the twelve Area Boards in England and Wales. These are intended to reflect the trend towards higher fixed costs and lower running costs, which have been brought about by the installation of more expensive, but more efficient, generating plant. From April 1, 1957, therefore, the fixed charge per kilowatt of maximum demand will be increased from £5 to £5 10*s*. 0*d*. for the first six months of the year of account; and to £6 for the remainder of the year. On the other hand, the running charge per kilowatt hour supplied will be reduced from 0·5 to 0·47*d*. (with fuel costs at 60*s*. per ton).

Another change is that, whereas hitherto the running charge payable by each Area Board for the whole of the kilowatt-hours supplied to them has been varied in accordance with the average cost per ton of coal consumed at the generating stations in that Board's area, as the 275 kV super-grid comes into operation, substantially increased transfers of electricity will take place from the low fuel-cost to the higher fuel-cost areas. The clause dealing with a variation in the running cost with the price of coal has therefore been altered so that an importing Area Board will benefit from any lower cost of fuel in the exporting area, after an appropriate charge for transmission has been made.

Because the grid system operates as a unified whole it is not, however, practicable to locate the source of, or to assess the costs of producing and transmitting the particular energy imported into any area, nor would it necessarily be equitable to do so.

For this reason such imports will be charged either on the basis of the calculated "residual" fuel cost, which represents as nearly as practicable the average fuel cost per ton of producing all the imported energy plus 6*s*. per ton for transmission costs; or on the Area fuel-cost if this is less than the "residual" cost. The amount of an Area Board's requirements not exceeding that generated by the combustion of fuel within its own area will, as hitherto, be charged on the basis of the area fuel-cost per ton.

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CO-OPERATION IN ELECTRICAL TRAINING

A one-day conference on education, arranged by the B.E.A.M.A. education committee, will take place at the Royal Festival Hall, South Bank, London, S.E.1, on May 8 next. It is being held with the object of sharing experience of technical training within the electrical industry, in order to foster a greater measure of inter-firm co-operation. Attendance will be restricted to representatives of member firms of the Association. Appliation forms are obtainable from the secretary, the British Electrical and Allied Manufacturers' Association, 36 Kingsway, London, W.C.2.

DESIGN PARAMETERS FOR DIESEL ENGINES

By G. T. Csanady, DIPL. ING.*

In his book on Diesel engine design, Walshaw† gives empirical figures for a number of seemingly independent design parameters such as brake mean effective pressure, mean piston speed, stroke-to-bore ratio, etc.

These data were apparently derived from good current design practice and, their conspicuous feature is that they show certain design parameters with relatively narrow ranges of variation for a given class of engine. For example, mean piston speed in stationary engines is 1,300 ft. per min. ± about 10 per cent., the number of engines with piston speeds outside these limits being very small. The obvious consequence of such well-defined empirical rules is that the choice of the designer is limited in deciding engine dimensions if the design is to conform to established practical principles. This fact is already apparent from the numerical examples cited by Walshaw; the relationships can, also be brought into explicit forms.

Consider first the brake mean effective pressure; it is evidently controlled by the fuel and air supply to the cylinder. If Q is the output per cylinder in b.h.p., s the specific fuel consumption in lb. per b.h.p.-hr., there is a supply of fuel to the cylinder of Q s lb. per hr.

For the theoretically perfect combustion of an average Diesel fuel, 14·5 lb. of air at atmospheric pressure are necessary per lb. of fuel; actually k times more have to be supplied, so that 14·5 k Q s lb. per hr. of air are required.

On the other hand the air supplied per cylinder may also be found from the swept volume and the specific volume of the fresh charge in the cylinder. This latter will be higher than the specific volume before entering the cylinder (i.e., in the atmosphere or after blower according to whether supercharging is employed or not), the ratio of the two volumes being by definition the volumetric efficiency.

Thus air supply is LAN 60 $\frac{1}{V_0}$ lb. per hr., where

L = stroke in ft.,
A = piston area in sq. ft.,
N = number of working strokes per minute,
$V_0 = \frac{V_i}{\eta_v}$ specific volume on induction, cub. ft. per lb.

The two expressions for air supply may be equated, resulting in

$$P = \frac{950}{k\,s\,V_0} \text{ lb. per sq. in.} \quad . \quad (1)$$

where the substitution $Q = \frac{PLAN}{33000}$ has been made and the factor 144 introduced to obtain the B.M.E.P. in lb. per sq. in.

An analysis of current engines will show that the values of k (for full load) and of s move in a relatively narrow range.

s = 0·38 ± 8 per cent.
k = 1·6 ± 10 per cent.

so that $P = \frac{1560}{V_0} = \eta_v \frac{1560}{V_i}$ for atmospheric induction. For example, if V_i = 12·4 cub. ft. per lb., then P = 126 η_v, and for η_v = 0·75, P = 94·5 lb. per sq. in.

Comparing supercharged with unsupercharged engines (assuming k and s constant),

$$\frac{P_s}{P_a} = \frac{V_{0a}}{V_{0s}}$$

where subscript s refers to supercharged and subscript a to atmospheric induction. If the absolute temperature of the charge remains approximately constant,

$$\frac{P_s}{P_a} = \frac{P_2}{P_1} = r,$$

the pressure ratio of the supercharging blower. This ranges from 1·2 to 1·5, and hence the increase in output due to supercharging is from 20 to 50 per cent.

Other useful relationships may be obtained by substituting the parameters v_p = 2 L n, the mean piston speed in ft. per min., where n = r.p.m., and $b = \frac{L}{D}$ (D = dia. of cylinder) into the conventional expression for output of piston engines:

$$Q = \frac{PLAN}{33000}.$$

This gives:

$$Q = \frac{PA\,v_p}{132000}, \text{ (for four stroke engines)} \quad (2)$$

$$\text{or } Q = \frac{PA\,v_p}{66000}, \text{ (for two stroke engines)} \quad (2a)$$

$$D = \frac{v_p}{2\,b\,n}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$Q = 1{\cdot}49 \times 10^{-6} \frac{P\,v_p^3}{b^2 n^2}, \quad . \quad . \quad . \quad (4)$$

(for four stroke engines)

$$\text{or } Q = 2{\cdot}98 \times 10^{-6} \frac{P\,v_p^3}{b^2 n^2}, \quad . \quad . \quad . \quad (4a)$$

(for two stroke engines)

If good practical values of v_p and b are substituted in the above expressions, the limitations of design become apparent;

with v_p = 1300 ft. per min.,

$$Q = \frac{PA}{101{\cdot}5} BHP \quad . \quad . \quad . \quad (5)$$

(four stroke engines)

with v_p = 1300 ft. per min. and b = 1·4,

$$D = \frac{464}{n} \text{ ft.} \quad . \quad . \quad . \quad . \quad (6)$$

$$Q = 1672 \frac{P}{n^2} BHP \quad . \quad . \quad . \quad (7)$$

(four stroke engines)

The values of output given by these expressions are for one cylinder; P is in lb. per sq. ft. and n in revolutions per minute, as stated above.

It can easily be verified that the last expressions yield mean values approximating to those given by Walshaw.

The reduction in the number of independent variables is seen to be thorough; specification of rotational speed, for example, fixes cylinder size and output (the latter provided induction is atmospheric; supercharging pressure is a further independent variable). In effect then, one datum approximately determines the entire layout of the engine.

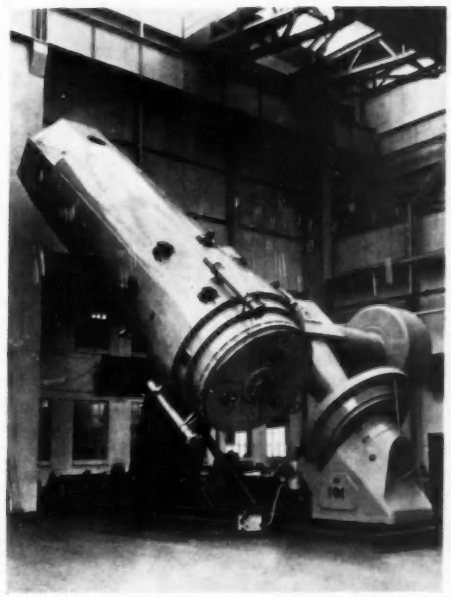
How far any variable can be chosen to differ from the mean value must be decided on more detailed investigation, for example, by consulting the graphs such as those given by Walshaw; for a first approximation, however, equations (6) and (7) in conjunction with (1) give quick results.

* Lecturer in Mechanical Engineering, N.S.W. University of Technology.

† T. D. Walshaw. "Diesel Engine Design" George Newnes Ltd., 1953.

AIR-CONDITIONED TELESCOPE

The telescope that has been built by Sir Howard Grubb, Parsons and Company, Limited, Newcastle-upon-Tyne, for the Saint Michel Observatory in the Basse Alpes, includes a number of advanced types of electronic receivers that will be tried out. In addition, the telescope will be air-conditioned to prevent distortions due to the air in the light path not being at a uniform temperature. By eliminating such distortions the errors in photography and spectographic readings will be reduced. The telescope, shown in the accompanying illustration, has a conventional parabolic reflector and a 75 in. aperture glass mirror. It is a universal instrument and has been arranged for use at the prime focus, Newtonian focus, Cassegrain focus or the Conde focus.



Fans, fitted in the outer casing, will air condition the telescope for the Saint Michel Observatory.

The main telescope tube has two sections, the inner one comprising fine woven nylon panels and the outer one being of sheet Duralumin. When the telescope is in use, air is extracted from the space between the two skins by 15 propellor fans made by Woods of Colchester. At the same time, atmospheric air is drawn down from outside the observatory dome into the interior of the tube, thus creating a continuous supply. Eight 15 in. diameter and four 12 in. diameter fans are fitted in the outer casing, all of them being diaphragm mounted, and three 9 in. ring-guard units are fitted in the base. Together these fans are rated to move approximately 14,440 cub. ft. of air per minute. Simultaneous control is provided by Woods regulators which will be mounted in a central control panel. The drive for the telescope is provided by electronic equipment and the speed can be kept constant to within one part in ten thousand. The final movement is through a worm and wheel.

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COMPUTER CIRCUITS

In the Ferranti "Mercury" computer, which is designed to operate at exceptionally high speeds, many of the circuit formations make use of the printing technique on account of the size of the components. It also eliminates the possibility of faulty connections in the wiring. They are made by Bakelite Limited, 12-18 Grosvenor-gardens, London, S.W.1. Laminated materials are used for the base and both rigid and flexible bases are employed. The adoption of this type of wiring has enabled the computer parts to be built into inter-changeable "packages" which can be replaced if necessary, with little delay.

BLASTING AND ASSOCIATED VIBRATIONS

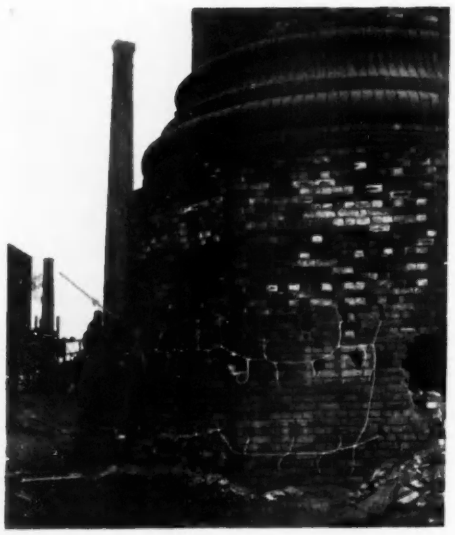
*By G. A. Teichmann and R. Westwater**

The investigation of vibrations, other than from blasting, is an every-day problem to the civil engineer. Trains passing over bridges, traffic along main roads, people walking over floors and wind stresses against buildings are but a few of the day-to-day examples of vibrations which are dealt with as routine calculations. Blasting vibrations, on the other hand, are not so well known, and have only been under intensive study during the last 10 to 15 years—in fact it is a type of vibration which has only been encountered on a major scale during the last decade when there has been an increase in the weight of explosive used and a tendency to blast close to property and structures. A fairly typical example is illustrated in Figs. 1 and 2 where a 100 ft. high chimney is shown being demolished. The magnitude of work now undertaken is illustrated in Fig. 3, where the face height of the quarry shown is about 90 ft.

The major difference between blasting vibrations and what might be termed industrial vibrations is the continuity of the latter over the sudden arrival and dying of the former. The authors have studied this problem in an endeavour to clear up some of the misconceptions relating to blasting vibrations and explain present-day views and methods applied to counteract problems arising from this cause.

BLASTING VIBRATIONS

Blasting vibrations are of short duration,



Figs. 1 and 2 A chimney over 100 ft. high being prepared for demolition and the resultant fall. A charge of about 70 lb. of explosive was placed in drilled holes and the holes fired simultaneously. Care was needed to make certain the chimney fell in the right direction and the shock from the explosive charge did not affect the nearby chimneys.

usually over in one or two seconds and consist basically of an initial high-frequency wave of low amplitude, followed or superimposed by low-frequency waves of varying amplitude dying down rapidly. Finally, there may be a second high-frequency wave caused by air blast.

The vibrations are of a sinusoidal nature with an exponential decay. It is not possible to produce a formula to fit all vibrations produced by blasting, but idealising the wave form, a near approach is covered by the formula:—

$$A = C e^{-kt} \cos p t$$

where A is the amplitude of the motion of the ground; t the time; C weight of explosive; p period of the site; and k is a constant proportional to the damping effect.

Though this formula approximates to a ground vibration received through a homogeneous stratum, only on rare occasions does this condition apply in the field, and the interpretation of ground-vibration characteristics depends on the solution for several wave trains approaching the structure in question along different paths.

Several types of wave form have been identified from vibration records and these waves can be divided into two basic groups. First, those which travel along the surface of the ground and cause a ground roll and, second, those travelling through the ground mass and giving rise to body waves.

Considering the ground waves, these can be divided into two sub-groups:—

(i) "Q" *Waves*, which is a shear wave moving transversely; and

(ii) *Rayleigh Waves*, which impart a motion, on a given particle of soil, similar to that obtained by the movement of a water wave on a floating cork, namely, an elliptical movement in a backward direction. Body waves can also be divided into two sub-groups:—

(*a*) *Shear Waves* similar to "Q" waves, but with a movement vertically as well as transversely.

(*b*) *Compressional Waves*, which produce a movement, as the name implies, in a push-pull manner.

An interpretation of a vibrogram does not necessarily entail the separation of these various forms as it is the amount or amplitude which a building moves at a given frequency which is the major governing feature of damage.*

TYPE OF EXPLOSIVE

There is a wide range of industrial explosives available to the civil engineer, and these can be divided into five main groups, the properties of which, from a vibration point of view, depend on (*a*) strength or power, (*b*) velocity of detonation, and (*c*) density.

These groups are:—

(*a*) *Blasting Gelatine.*—A high strength, high density (1·5 to 1·6 gm. per c.c.) and high-velocity explosive.

(*b*) *Gelignites* (which include the gelatines and the special gelatines).—A range of explosives from high to low strength with a high density (1·5) and medium velocity.

(*c*) *Semi-Gelatines.*—A range of explosives with similar relative weight strengths but varying relative bulk strengths produced by varying the density from 1·3 to 0·95; their velocity is medium-high.

(*d*) *T.N.T./Ammonium Nitrates.*—Generally a high weight strength, medium density (1·1) and a velocity slightly higher than the gelignites.

(*e*) *Powders and Bag Powders.*—High relative weight strength, low density and medium-low velocity.

It can be deduced that all these types can produce different intensities of seismic energy in the form of ground waves. The higher the strength of the explosive, the more concentrated the charge will be in the hole and, therefore, the greater the seismic shock. Similarly, the higher the velocity of the explosive, the greater the shock is likely to be and, more important, the greater the associated air blast.

When an explosive is detonated in confinement, its energy is consumed in breaking, fracturing and heaving out the material in which it is confined, as well as producing a seismic shock. If a shot is "balanced" the bulk of the energy is expended in breaking the material and, in the case of a quarry, heaving it out on to the quarry floor, only a small proportion of the energy being dissipated into the surrounding strata.

Often, however, holes charged with explosive are not properly balanced, so that the explosive is required to do either more or less work than it is capable of doing. Under these conditions, the high-strength explosives are liable to produce a higher ground amplitude at a given distance than a low-strength explosive. This increase in amplitude is small and is often masked by non-homogeneous strata. Furthermore, an over-charged hole will also produce excessive air blast, which, though in itself may not cause damage, may be considered to be a nuisance within the law.

The density of an explosive will again alter the amplitude of the ground vibrations because a low-density explosive, compared pound for pound with a higher density explosive, will fill a greater column length in the drilled hole, and as a result, it can act to a greater extent on the surrounding rock doing more useful work, thus reducing ground vibrations.

SITE INFLUENCE

The amount of energy released from a given blast will give rise to a ground wave, which will vary according to the type of rock or soil through which it travels. For example, the frequency of this seismic disturbance will be higher when travelling through rock than when travelling through an overburden of clay or gravel. As the great majority of structures are not keyed into bed rock, the frequencies associated with soil are the most important and, as far as blasting is concerned, these frequencies lie usually within the range of 3 to 16 c.p.s. If the structure is keyed into bed rock, the frequency may be within this range but is often somewhat higher, reaching 25 to 50 c.p.s. or more.

The amplitude of the seismic disturbance will depend on the resistance of the rock or soil to distortion. The resistance of rock is high and amplitudes will be small in relation to clay and top soils, which will give a higher amplitude for a given energy "input." It is a common belief

* Both of Imperial Chemical Industries, Limited, Nobel Division, Bothwell-street, Glasgow.

* G. Morris, "The Reduction of Ground Vibrations from Blasting Operations," ENGINEERING, vol. 169, page 430 (1950).

Fig. 3 A 90 ft. high limestone quarry face being blasted with 2½ tons of explosive to provide 25,000 tons of broken rock for agricultural purposes.

that structures situated on a thick clay bed are less likely to be affected by blasting than those built on rock. This is not true, and this belief is often due to the higher human susceptibility to amplitude of high frequency than low frequency. Clay has a lower resistance to stress than rock and so vibrates, though with a low frequency, at a higher amplitude, for a given energy input. Thus, buildings on clay are subject to greater movements and, therefore, are more likely to be damaged.

The amplitude of the ground movement associated with a given blast will vary according to the distance from the blast to the recording point, and provided the ground is reasonably homogeneous it will diminish proportionately with distance.

It is useful to co-ordinate these three factors, explosive charge, distance and site factor, into a common formula.

The United States Bureau of Mines carried out a series of experiments and obtained a relationship of:—

$$A = \frac{E^{\frac{3}{4}}}{100}\,(0{\cdot}07e^{-0{\cdot}00143d} + 0{\cdot}001)$$

where A = maximum amplitude (in.), E = weight of explosive (lb.), and d = distance (ft.).

This relationship for the variation met with in the field would appear to be too complex and Morris* suggests the relationship:—

$$A = \frac{k\sqrt{E}}{d}$$

where A = maximum amplitude (in.), k = site factor, E = explosive charge (lb.), and d = distance (ft.).

This formula is of more general application and can be used after a rough appreciation of the geology has been obtained in respect of the uniformity of the locality. The constant k used in the formula will vary according to the conditions on the site, so that, if the site is a type which vibrates easily, k will be high, and vice versa. Typical values of k taken in association with blasting on three groups of sites are given in Fig. 4.

From a large number of recordings, rough limits for k can be ascertained from Table I. Under severe conditions, such as running sand, k may reach as high as 0·40 to 0·50.

TABLE I *Values of Site Factor k*

Conditions of blasting	Position of structure	k
Rock	Rock	0·05—0·10
Rock	Clay	0·10—0·20
Clay	Rock	0·10—0·20
Clay	Clay	0·20—0·30

* G. Morris, "Vibrations Due to Blasting and their Effects on Building Structures." *The Engineer*, vol. 190, pages 394, 414 (1950).

This formula is reasonably accurate over various distances and charges and the accuracy is well illustrated by Leet, who described the largest quarry blast ever fired. This blast contained 1,362,985 lb. of explosive fired in a coyote blast near South Holston, Tennessee. Vibration recordings at 8,000 ft. gave the maximum displacement as 0·027 in. and at 11,500 ft., 0·018 in. With these figures, the calculated value of k, at the two recording points, is 0·184 and 0·177 respectively, a difference of only 4 per cent.

It will be noted that this formula does not take into account the frequency of the site and unless the frequencies associated with blasting lie within the range 3 to 16 c.p.s., a suitable safety factor has to be added to the normal recommended maximum amplitude, A. As blasting frequencies are quite often within the 3 to 16 c.p.s. range, the importance of leaving the frequency out of the formula is not great. Typical frequencies associated with maximum amplitude on three groups of site are given in Fig. 5.

ALLOWABLE GROUND MOVEMENT

Having established the relationship $A = \frac{k\sqrt{E}}{d}$, it is useful to use this formula as an indication of the maximum ground movement that can be given to a structure without damaging it. Morris, in association with Born and Pugh*, has attempted to calculate the strength of a structure by considering a group of brick piers which will have a low resistance to damage by vibration. Morris calculates that the limiting horizontal amplitude which will just cause cracking of the pointing at an average blasting frequency is 0·016 in. These calculations are based on the assumption that the building does not resonate with the ground frequency, though harmonics are considered. As a brick pier is a weak structure, Morris's calculation can be considered to be a reasonable one.

Practical examples of damage to property which can be conclusively proved to blasting are few and far between and, because of the few examples available, several "limiting" relationships have been established. The relationship used in this country is independent of frequency. Thoenen and Windes of the United States Bureau of Mines consider the product:—

$$f^2 A$$

where f = frequency (c.p.s.), A = amplitude (in.). If f^2 A exceeds 10, then the threshold of damage is reached.

Crandell, working on behalf of a United States Insurance Company, suggests fA as a suitable relationship and quotes fA = 0·745 as the damaging level.

Both these relationships are given with safety factors; in the former f^2 A $\ll$ 1 and fA $\ll$ 0·527 in the latter. Morris and Westwater* have considered four known cases of blasting damage and compared the above three formulae. The details of these blasts are summarised in the accompanying Table II.

In all these cases the result of only one blast is considered and the cumulative effect of a number of blasts may show damage at a lower amplitude. However, in all cases the limiting amplitude suggested by the authors is within the safety limit.

In each of the buildings, the damage was associated with plaster cracks. A building, or structure, which is of more robust construction and has not any plaster, or where plaster cracks are immaterial, can withstand a much higher ground movement safely. This applies particularly to quarry plant, factories (without delicate machinery) and massive structures such as concrete dams, etc.

Because of the variation in the types of structure it has been recommended that they should be broadly classified into four groups:—

(*a*) Structures of great value and frailty. This will include certain ancient monuments, such as churches and certain badly designed properties.
(*b*) Property, houses, etc., closely congregated.
(*c*) Isolated property.
(*d*) Civil engineering structures.

Taking suitable safety factors and after the site has been investigated by a vibrograph, caution limits are applied. These limits are usually 0·004, 0·008, 0·016 and 0·030 in. respectively. In very exceptional conditions, as much as 0·070 in. can be applied (see Table III). It is interesting to note that the Department of Mines, Pennsylvania, in relation to blasting in strip-mine operations in the anthracite region, have recommended that "in no case shall the ground displacement be in excess of 0·03 in. at

* M. Born and H. Ll. D. Pugh, "Vibration of a Thin Vertical Cantilever Caused by a Damped Harmonic Disturbance of the Ground," *Jl.I.C.E.*, vol. 18, page 279 (1942).

* G. Morris and R. Westwater, "Damaged Structures by Ground Vibrations Due to Blasting," *Mine and Quarry Engineering*, vol. 19, No. 4, page 116 (1953).

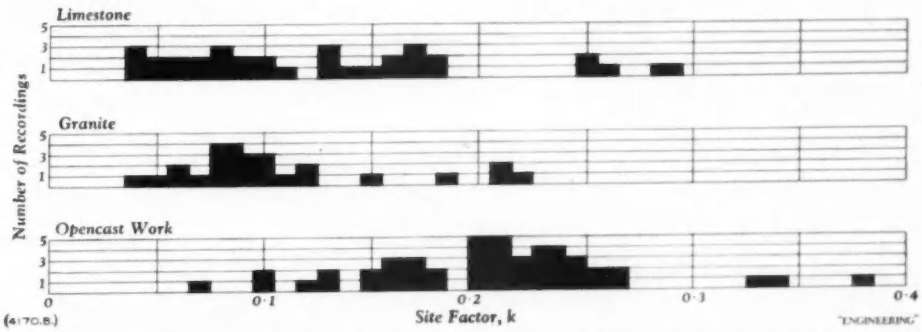


Fig. 4 Graph showing the variation in the "site factor" on different types of ground. The higher the site factor, the greater the ground oscillation due to a given blast.

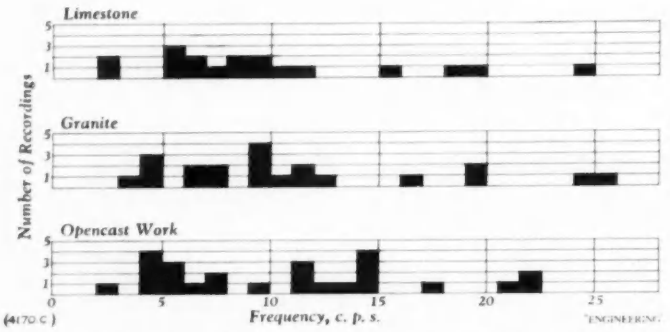


Fig. 5 Graph showing the variation of ground frequency with types of ground. The higher the frequency, the more readily the ground vibration can be felt.

any dwelling house, public building, school, church, commercial or institutional building." The Department of Labour and Industry, New Jersey, have also laid down regulations allowing the same displacement up to a frequency of 10, and half that figure up to a frequency of 20. The two sets of regulations are given in some detail in appendices 1 and 2, respectively.

HUMAN SUSCEPTIBILITY

Complaints are often received of excessive vibration based on the fact that they feel severe. The susceptibility of human beings to vibration depends on the frequency as well as the amplitude of movement.

Reiher and Meister* made a full study of continuous vibrations in relation to humans of various ages and in various positions. They found that the age of the person affected their reaction to shock and also the position and activity of the person at the time (i.e., lying down or standing up). This different reaction between person and person will often account for complaints received in the field.

In Fig. 6 curves have been drawn giving the noticeable amplitudes associated with a given frequency based on work carried out by the authors in amplification of Reiher and Meisters' work. It will be seen that within the range of blasting vibrations, most movements over 0·0015 in. can be felt. This movement, however, is only just perceptible; a larger one has to be applied before it is generally perceptible, and even a larger movement can be applied before the disturbance can be classified as a nuisance or unpleasant if frequent. These lines have been drawn on the graph representing the vibration which might be classified as unpleasant if fired at regular intervals. If a blast is only fired at irregular intervals, such as coyote or heading blasts, occasional well-hole blasts or once-only blasts, such as in road cuttings, a larger amplitude can be apportioned without being considered unpleasant. Cases can also be quoted where people have become accustomed to blasting vibrations and movement is not noticed.

It will be seen that the 0·008 and 0·004 in. limit recommended for closely congregated property and property of great value, as far as average blasting frequencies are concerned (3 to 16 c.p.s.), lie almost entirely within the noticeable and unpleasant lines. Therefore, before a final amplitude limit is apportioned to any site, consideration must be given to the human reaction to blasting and, though damage may not result to buildings, the movement may be such as to cause considerable apprehension—and claims.

* *Die Empfindlichkeit des Menschen gegen Erschutterungen Gebiete Ingenieur*, 1931.

AIR BLAST

About three-quarters of all complaints arise initially from air blast, and although cases can be given where a blast of 5 to 10,000 lb. of explosive is fired without any complaint yet a series of 2 to 4 oz. pop shots may cause trouble. Though air blast will seldom cause damage, every effort should be made to reduce it to a minimum. The four main causes of air blast are overcharged holes, blow outs, poor stemming, and uncovered Cordtex.

Air blast is also affected by the strength and velocity of the explosive. The higher the strength and the higher the velocity, the greater the associated air blast.

Complaints are likely to be sporadic, as air blast is affected by wind and weather conditions. A high wind will tend to carry the sound waves in the direction that the wind is blowing and most complaints will be received from this direction. Other conditions that affect air blast are low cloud ceiling, rain, mist and fog, all of which will cause reflections of sound waves and concentrate effects in local areas.

Air blast consists of an initial concussion wave followed by a rarefraction. Work carried out during the war indicates that it is the positive pressure or the concussion wave which is the more closely related to the damage resulting to a building.

As explosive does some useful work whilst used for industrial bla ting, it is impossible to produce a working formula to calculate air blast at a given distance from the weight of explosive used in a given blast, though an estimate of the amount of explosive wasted and causing air blast can often be assessed.

The impulse produced by this explosive can be represented by

$$I = k \frac{E^{\frac{1}{2}}}{d}$$

where I is the positive impulse (lb. sec. per sq. in.); E, the weight of explosive (lb.); d, the distance (ft.); and k a constant (this varies with the explosive, but for all practical purposes can be taken as 0·10).

If I exceeds 0·01 lb. sec. per sq. in., damage in the form of broken glass can be expected, though glass under tension or badly mounted may break at half this figure.

More serious damage from air blast can be anticipated if I reaches 0·04 lb. sec. per sq. in. Because of the psychological aspect, air blast should be kept down below a figure of 0·001 if at all possible.

REDUCING GROUND VIBRATION

The effect of ground vibration is twofold. The first is its possible nuisance value which depends on the number of times the vibration is produced in a given period, that is, its frequency. To reduce nuisance to a miniumum, the frequency of the site must be known and then the results tied into Fig. 4.

The second is its damaging effect which at blasting frequencies is approximately proportional to the amplitude. To reduce the amplitude, the instantaneous charge fired at any time must be reduced.

The effect of air blast is mainly psychological, but should in any case be kept to as low a level as is economically possible.

To reduce the ground amplitude, it is necessary to reduce the instantaneous charge fired. In many cases it is not possible to reduce, and often it is preferable to increase, the total charge of explosive. However, if this charge can be broken up, as will occur if a number of shotholes are loaded with explosives, then the ground vibration can be reduced by firing each hole at an interval instead of instantaneously. It has been found in practice that this interval need only be of the

TABLE II

Site	Structure	Charge (lb.)	Distance (ft.)	Damage	f	Recorded amplitude	Calculated amplitude (in.)				
							Crandell		U.S.B.M.		Nobel caution
							Caution	Damage	Caution	Damage	
U.S.B.M. ..	Frame and brick farmhouse	105	70 below 30 away	Cracking old plaster	14	0·090	0·038	0·053	0·005	0·050	0·016
Quenist, Belgium	Dwelling house	—	—	Nil	16	0·041	0·033	0·047	0·004	0·040	0·016
Opencast coal site, England	Old stone farmhouse	200	115	Heavy cracking of plaster near wall joints	3·7	0·080	0·142	0·201	0·072	0·720	0·016
Quarry, Scotland	Stone house	14,000	820	Slight cracking of plaster and slates displaced	5·7	0·040	0·092	0·131	0·030	0·300	0·016

TABLE III LIMITING INSTANTANEOUS EXPLOSIVE CHARGE IN POUNDS

Distance, ft.	A = 2 × 10⁻³ in.					A = 4 × 10⁻³ in.					A = 8 × 10⁻³ in.					A = 16 × 10⁻³ in.				
	Values of k					*Values of k*					*Values of k*					*Values of k*				
	0·10	0·15	0·20	0·25	0·30	0·10	0·15	0·20	0·25	0·30	0·10	0·15	0·20	0·25	0·30	0·10	0·15	0·20	0·25	0·30
100	5	2	—	—	—	15	7	5	3	2	65	30	15	10	7	250	90	65	40	30
200	15	7	5	—	—	65	30	15	10	7	250	100	65	40	30	1,000	350	250	150	100
300	35	15	10	5	5	150	65	35	25	15	575	250	150	90	64	2,300	800	575	350	250
400	65	30	15	10	7	250	100	65	40	30	1,000	450	250	150	110	4,000	1,400	1,000	650	450
500	100	45	25	15	10	400	175	100	65	45	1,600	700	400	250	175	6,500	2,200	1,600	1,000	700
600	150	65	35	25	15	575	250	150	90	65	2,300	1,000	575	375	250	9,000	3,200	2,300	1,500	1,000
700	200	85	50	30	20	775	350	200	125	85	3,100	1,400	775	500	350	12,000	4,300	3,100	2,000	1,400
800	250	110	65	40	30	1,000	450	250	150	110	4,000	1,800	1,000	650	450	—	5,700	4,000	2,600	1,800
900	325	140	80	50	35	1,300	550	325	200	140	5,000	2,300	1,300	800	550	—	7,200	5,000	3,300	2,300
1,000	400	180	100	65	45	1,600	700	400	250	180	6,500	2,800	1,600	1,000	700	—	9,000	6,500	4,100	2,800
2,000	1,600	700	400	250	180	6,400	3,000	1,600	1,000	700	—	11,000	6,400	4,000	3,000	—	—	—	16,000	11,000
3,000	3,600	1,700	900	575	400	14,000	6,400	3,600	2,300	1,700	—	—	14,000	9,000	6,400	—	—	—	—	—

TABLE IV

Delay No.	Nominal mean delay, milliseconds	Delay No.	Nominal mean delay, milliseconds
1	25	8	265
2	50	9	305
3	75	10	345
4	100	11	400
5	150	12	465
6	185	13	535
7	225	14	615
—	—	15	700

order of milliseconds and a range of detonator devices* are available for this purpose, namely:—

(*a*) *Delay Detonators.*—These detonators will fire at half-second intervals with a range of 0 to 5 seconds (11 delays). Their use is mainly limited to tunnelling.

(*b*) *Short-delay Detonators.*—Short-delay detonators can be obtained with delay periods of from 25 milliseconds up to about 75 milliseconds in a range of 15 delays. The mean delay periods are given in Table IV.

(*c*) *Detonating Relays.*—This is a device which can be inserted in a main line of detonating fuse, such as Cordtex, which will produce a standard delay of 17 milliseconds. And,

(*d*) *Nobel Delay Switch.*—This device will give any delay from 7 milliseconds to 100 milliseconds, when used with a special electronic exploder.

DELAY FIRING AT THREE CONTRACTS

The exact reduction of ground vibration by the use of delays will depend on the delay interval, the frequency of the site and the type of ground. The ideal delay time can only be obtained by a vibrograph analysis of the area, but, as a rough guide, about two-thirds of the instantaneous charge can be fired on each delay without increasing the ground vibration; except when blasting in the immediate vicinity of property where the influence of the shear and compression waves may reduce the short delay charge to a greater extent.

Examples of large explosive charges fired within close proximity of property, in the case of three contracts, are given below.

Contract I.—This job concerned the excavation of approximately 5,000 cub. yd. of stratified limestone in a rectangular area of 113 ft. by 156 ft. to an average depth of 8 ft. The area had roads on two sides and a house on one; at the nearest point, the house lay only 3 ft. away from the excavated area. A 16 in. cast-iron water main, carrying the city's principal water supply, ran within 8 ft. of the excavation.

To work the area, an opening cut was made using a 3 ft. by 3 ft. drill pattern, loading the holes at the rate of 1 lb. of explosive per cub. yd. After blasting this cut, further blasts were fired into this area using multiple rows of holes on a pattern of 3 ft. by 3 ft. or 3½ ft. by 3½ ft. loaded at a rate of 0·75 lb. of explosive per cub. yd. The majority of the holes were 8 ft. in depth and charged with 2 to 2½ lb. of explosive, which was spread along the holes by spacers so that the final stemming averaged 3 ft. The multiple row shots were delayed by rows, using a 25 millisecond interval, with a further similar interval for the end holes of each row, except when blasting near to the house or in trimming up, when the holes were also delayed within the rows. Blasting mats were used on the initial blasts, but as experience was gained these were no longer used and all blasts were successful, producing no fly rock, concussion or vibration.

Contract II.—On the second contract a large shop in the centre of a city was extending its site, requiring the excavation of 7,300 cub. yd. of rock. The shop had to remain in commission during the excavation work and traffic could not be interferred with unduly, so that fly rock and vibration had to be reduced to the minimum.

The contractors worked the site by first stripping the overburden to a depth of 28 ft., which left an area of rock 7 ft. thick to blast. This was removed by opening a box cut at one end of the site and subsequently blasting trenches of varying dimensions towards the free faces thus produced. A standard drilling pattern of 2½ ft. by 2½ ft. was used except when blasting against the walls of buildings, when the pattern was reduced to 1½ ft. by 2½ ft.

Blasts were loaded on a basis of from 1·5 lb. per cub. yd. down to 0·5 lb. per cub. yd., and the amount fired at one time varied according to the distance away from buildings. Thus, at a distance of 50 ft. from the shop, typical weights were approximately 30 lb. of explosive distributed in 20 holes of 1½ lb. per hole. Up to four of these holes were fired on any one short-delay detonator. At a distance of 10 ft., charges of 10½ lb. were used in 14 holes, each hole being fired on a different delay. Although various depths of rock up to a maximum of 8 ft. were blasted within a distance of 3 ft. of the main building, no damage was caused. At this proximity, however, and where the holes exceeded 5 ft. in depth, two charges were used in each hole separated by 3 ft. of dry-sand stemming and primed with consecutive short-delay detonators.

Contract III.—On the third contract, a 17 ft. diameter tunnel was being driven under the main buildings in the centre of a city, the depth below the building foundations being between 90 ft. and 120 ft. A wedge cut was planned using a total of 45 holes and a total charge in excess of 150 lb. Each group of holes was fired with a half-second delay with a maximum charge fired on any delay period of 30 lb. No damage was caused by this blasting, but as the ground movement was felt on the surface the charges fired at each delay were halved towards the end of the contract.

RECORDING METHODS

Where a problem regarding ground vibration is likely to arise, it is usually necessary to make a vibrograph investigation in order to be able to analyse the site. There are two standard vibrographs which are at present in use, namely, the Nobel Vibrograph and the Cambridge Vibrograph.

The former instrument has been specially designed for blasting vibrations and will pick up the horizontal compressional or transverse components of the shock wave. The instrument is illustrated in Fig. 7, and consists essentially of a pendulum on to which a beam of light is thrown. The reflection from the pendulum is recorded on a revolving photographic drum.

The Cambridge Vibrograph, shown in Fig. 8, will record the vertical, horizontal or compressional ground wave components. The movement is inscribed on a celluloid tape by a special stylus, and the recording can be magnified by a projector, giving a total magnification of 50. The instrument is more portable than the Nobel Vibrograph, but will generally only record frequencies over 5 cycles per second and frequencies between 5 and 10 cycles per second required to be corrected.

LEGAL ASPECTS*

The formulae given in the last pages have been worked out along theoretical and practical lines and are now commonly accepted in the form given or along modified forms over most of the world. The authors are of the opinion that the safety factors applied to these formulae are fair and safe and, on the basis of the 60 cases a year of problems relating to blasting vibrations that are handled by the authors they think it is reasonable to assume that the formulae are satisfactory. Because of the few cases of litigation, it is not absolutely clear what constitutes a damaging ground vibration or a nuisance, but it is useful to know on what basis these cases are liable to be fought, and the following is a personal appreciation of the law, by the authors, as it now appears to them to stand at the present.

The three cases that have been fought which affect the issue are: *Walter v. Selfe*, 1851 (nuisance); *Rylands v. Fletcher*, 1866 (damage); and *Swindells and Another v. Naybro Stone Limited*, 1955 (vibration).

In the case of *Walter v. Selfe*, a judgment was given on what constituted a reasonable interference of people's rights:

> "Ought this inconvenience to be considered in fact as more than fanciful, more than one of mere delicacy or fastidiousness, as an inconvenience materially interfering with the ordinary comfort physically of human existence, not more according to the elegant or dainty modes and habits of living, but according to plain and sober and simple notions among the English peoples?"

The case of *Rylands v. Fletcher* refers to a man who had a reservoir built on his land. Unknown to him the reservoir was built over a disused coalmine shaft and as a result the water from the reservoir flooded workings of a nearby mine. The man was found liable for the damage, despite the fact that no negligence was involved. In the judgment it was said:

> "We think that the true rule of law is that the person who for his own purposes brings on his lands and collects and keeps there anything liable to do mischief if it escapes must keep it in at his peril, and if he does not do so is *prima facie* answerable for all the damage which is the natural consequence of its escape."

In the case of *Swindells and Another v. Naybro Stone Limited*, the plaintiffs complained that over a period of some four years, the defendants had carried on blasting operations at their quarry, the result of which had been to cause serious damage to the plaintiffs' house and had substantially interfered with the comfort and/or convenience of the plaintiffs' occupation. The judge, on evidence based on the principles of vibration discussed earlier in this article, found that no damage had been caused to the property by vibration resulting from the blasting and issued judgment for the defendants.

Numerous cases fought in the courts since the Rylands case have expanded the law, and a distinction was drawn between the natural and non-natural use of land—the law only being applicable in the latter case. It would appear that quarrying and blasting is a non-natural use of the land.

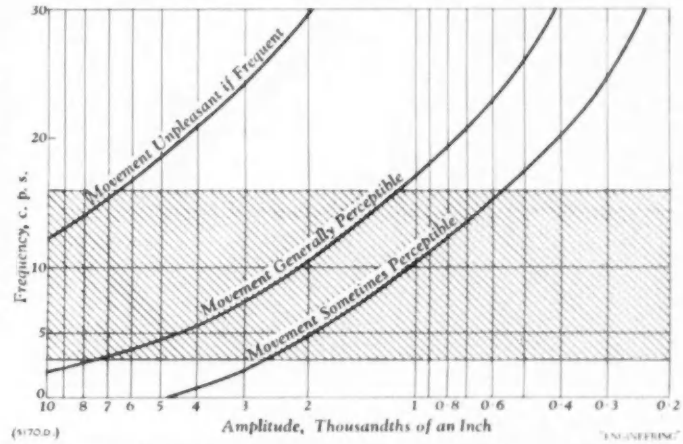


Fig. 6 A graph showing the average effect on people of ground vibrations produced by blasting: the higher the frequency, the lower the ground movement that can be felt. The shaded area (3 to 16 c.p.s.) represents the normal range of blasting vibrations.

* Full details of these devices are available from any explosives manufacturer.

* This is a personal appreciation of the law, which the authors feel relates to blasting vibrations.

Fig. 7 (above) The Nobel Vibrograph designed to record photographically the horizontal components of ground movements resulting from blasting.

Fig. 8 (right) The Cambridge Vibrograph designed to record mechanically all components of the ground movement produced by industrial vibrations.

Nuisance in law can be broken down into two kinds—public and private. A private nuisance is a civil wrong and takes in the case of the escape of deleterious things into another person's land—e.g., vibrations* and noise,† whether continuous, intermittent or isolated.

In the case of vibrations or air blast, there can be no action for nuisance unless it has caused actual damage to the plaintiff. The definition of damage is wide and takes in the case of physical damage to property as well as the effect on the beneficial use of the property in as much as it may reasonably interfere with the people using this property. In other words, if it interferes with the beneficial use of property it can amount to an actionable nuisance, though such cases are exceptional.

However, a person living in a given district cannot grumble if he receives noise and vibration which is common to that district, as naturally a town will have more vibration and noise than a country village, a main road to a side road, a mining district to an agricultural area, and so on. This point was brought out in *Nunns v. Wilcock*: in this case the plaintiff claimed damage to his property and injury to his and his wife's health, due to blasting vibrations.

The fact that a quarry on another site has been in operation and causing vibration or noise to excess for a number of years before land is occupied does *not* preclude claims of damage and nuisance.‡ If, for example, a plot of land next to a quarry is built upon and even assuming the owner of this property is aware that vibrations from the quarry will damage his property or cause a nuisance, he is still entitled to claim against the quarry. Furthermore, it is no defence§ to claim that a given property was old and badly designed, and, therefore, weaker than a normal structure.

The only exemption to claims of nuisance of this type is if the defendant can prove the right to commit a private nuisance. Subject to certain conditions, this right may become legalised if the nuisance has been in existence continuously for 20 years, though this right applies to a given property and not to extensions of the property or new property which might be developed.

It is evident that where there is a possibility of complaints it is preferable to call in the services of a seismologist or explosives engineer trained to deal with these problems who will be able to give a reasoned approach to the subject. It is valuable to use these services also when complaints are not likely to arise, but where some civil engineering structure (such as a dam) is nearby, and the maximum quantity of explosive that can be fired without deleterious effects is unknown.

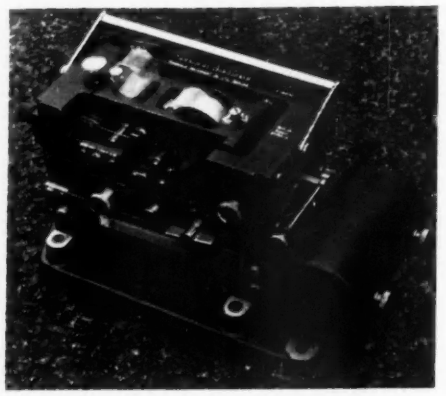
* *Hoare* v. *McAlpine*, 1923 (Pile-driving).
† *Polsue and Alfierie, Ltd.* v. *Rushmer*, 1907 Machinery).
‡ *Bliss* v. *Hall*, 1838.
§ *Hoare* v. *McAlpine*, 1923.

Appendix I

Rules Governing Blasting in Strip Mine Operations in the Anthracite Region, Pennsylvania.

Act No. 472, approved June 27, 1947. Section 20 reads as follows:—

"The use of explosives for the purpose of blasting in connection with strip mining in the neighbourhood of any public highway, stream of water, dwelling house, public building, school, church, commercial or institutional building or pipe line shall be done in accordance with regulations prescribed by and under the supervision of the Department of Mines."



To meet the requirements of Section 20 of the Anthracite Strip Mining Act, the following rules, were adopted on August 8, 1948:—

(1) In no case shall the ground displacement be in excess of 0·03 inches at any dwelling house, public buildings, schools, churches, commercial or institutional buildings.

(2) Where a blast is to be fired within 200 ft. of a pipe line, the operator shall exercise such necessary caution as may be needed for the protection of the pipe line. The operator should also notify the owner of said line of his intention to blast as here described, giving a description of the precautionary measures that will be taken.

(3) Blasting shall be prohibited in all cases where the effect of such blasting is liable to change the course or channel of any stream, without first obtaining a permit from the Water and Power Resources Board.

(4) No blasting shall be done so close to the banks of a stream that the banks would be ruptured or broken permitting the water to enter the strip mine pit.

(5) Public highways shall be barricaded and guarded by the operator in all cases where such highway or highways are located within 800 ft. of any point where a blast is about to be fired.

(6) Mudcapping will be permitted only where it would endanger the safety of the workmen to drill the rock to be blasted.

(7) If mudcapping is necessary, a maximum of 10 lb. of powder may be used.

(8) All trunk lines of Primacord should be covered. However, trunk lines of Primacord must be covered if they are within 2,000 ft. of such buildings as outlined in Section 20 of Act No. 472.

Appendix II

Extract from the Rules and Regulations Governing Quarry Blasting and Related Operations, New Jersey.

Pursuant to the provisions of the State Explosives Act, the Commissioner of Labor and Industry is empowered to "... make such rules and regulations, to have the force and effect of law, which may be required to facilitate the administration and enforcement of the provisions of this act."; with the direction, in part, that the Commissioner shall be therein guided ... "by considerations of safety to life and limb of persons, and preservation of property ..."

The more important of the rules referred to above are as follows:—

Allowable Limits.—Allowable limits of ground motion and sound pressure contained in this section shall be considered neither to produce structural damage in any structure that has been reasonably well constructed according to accepted engineering practice nor to constitute a nuisance to persons.

Restrictions on Quantity of Explosives.—All primary shots shall be fired with quantities of explosives not in excess of those permitted by this section and except as further restricted by other requirements of those rules and regulations.

Frequency-Amplitude Relations.—When ground frequency and displacement characteristics in relation to known quantities of detonated explosives in primary blasts have been determined by approved means of instrumentation to the satisfaction of the Commissioner the allowable limits of the maximum amplitude of ground vibrations related to frequencies of vibration shall be as indicated in the following table.

Table of Frequency-Amplitude Relations

Frequency of ground motion, cycles per second	Maximum amplitude of ground motion, in.
Up to 10	Not more than 0·0305
20	0·0153
30	0·0102
40	0·0076
50	0·0061
60	0·0051

Allowable Quantities of Explosives.—Without approved methods of instrumentation, the quantities of explosives used in any primary blasting shall not exceed those given in the following table.

Quantity-Distance Table

Distance from blast area to nearest structure, neither quarry owned nor quarry leased, ft.	Maximum quantity of explosives per shot for instantaneous firing or per delay for delay firing, lb.	
	Normal overburden	Abnormal overburden
100*	340	70†
200	420	78
300	525	100
400	635	125
500	800	160
600	950	200
700	1,175	245
800	1,500	300
900	1,830	360
1,000	2,250	430
1,200	3,500	610
1,400	—	820
1,600	—	1,250
1,800	—	1,900
2,000	—	3,000

* Minimum allowable distance when approved missile protection methods are used.
† More than 50 ft. to bedrock.

Variations in Quantity-Distance Relations.—When ground motion characteristics for any given quarry operation have been determined by the Commissioner, based on instrumentation data submitted by the operator, the allowable quantity-distance relations between amount of explosives used in primary blasting and distance from blast area shall be determined from the accepted results of instrumentation at the given quarry operation for the various weights of explosives. The maximum amplitudes shall not exceed those given in the table of frequency-amplitude relationships.

Allowable Sound Pressure.—The maximum allowable sound pressure beyond quarry property lines resulting from quarry blasting shall not exceed 100 decibels.

Seismograph Records.—If siesmograph or air pressure readings, or both, are taken upon

authorisation of the operator of any quarry, a copy of the covering seismograph report shall be forwarded to the Commissioner without delay together with a copy of the records (which are required to be maintained) in order to provide basic data for research and study of seismic effects.

Recorded Seismograph Data.—Seismograph reports shall include identification of instrument, name of observer, name of interpreter, distance and direction of recording station from the area of detonation, type of ground at recording station or location in structure, maximum amplitudes for all components as well as resultant for all recorded frequencies of vibrations, duration of motion in excess of one one-thousandth of an inch; a copy of the photographic record of seismograph readings.

Qualifications of Seismologist.—Seismograph reports shall be signed by a person whose qualifications are satisfactory to the Commissioner, in order to be given any consideration by the Commissioner for modification of quantity-distance relations permitted (as above). Such person shall be held responsible for the authenticity and correctness of such reports.

Book Reviews

SMOOTH PATHS OVER ROUGH GROUND

Mathematics is Easy. By D. S. WATT. *Princes Press, Limited, 147 Victoria-street, London, S.W.1.* (48*s.*)

This book is one among many that, consciously or unconsciously, owes its inspiration to Silvanus P. Thompson's *Calculus Made Easy*, a little classic first published many years ago. That title is undoubtedly a better one than "Calculus is Easy" would have been, for it does not imply, as the uninitiated might rashly suppose, that original discoveries in the calculus, or in any other branch of mathematics, were or are made without effort. It does, however, suggest that, once the pioneers have fashioned new mathematical tools, it is not unduly difficult for normal mortals to be taught how to use them to advantage. The tools, in fact, are in some respects so perfectly adapted to their purpose that many types of mathematical manipulation can be accomplished with a close approximation to complete absence of thought. Put a tramcar upon its rails, set it into motion, and the rails will automatically conduct it to the terminus.

Whether or not any particular individual finds mathematics easy will depend upon his interest in, and innate aptitude for, the subject, on his capacity for steady application along the right lines, and on how far he aims to penetrate into its higher and more abstruse reaches. Progress in mathematics, more than in most subjects, demands a sound grounding, so that expert guidance and judicious encouragement are particularly desirable in the early stages. Much subsequent confusion can be avoided if care is taken at the outset to distinguish clearly between the initial assumptions made, the line of reasoning to be pursued, and the end in view.

All these principles the author of this book seems to have had in mind though it is open to doubt whether his exposition is always calculated to exemplify them to the best advantage. It is disconcerting in these days of compulsory general schooling (often incorrectly described as universal education) that he should have felt it necessary to discourse at such length on the simple arithmetical operations or on fractions and decimals. Again, although stress is rightly and repeatedly laid on the necessity of working examples, none are provided, apart from those worked out in the text. "If your brother, father, sister, aunt or neighbour is a mathematician," the reader is instructed, on page 198, "to ask kindly for examples of indices. Failing that, go to a library and consult books on algebra and search for countless examples on indices." Contradictory but saner advice is offered on page 211: "Don't spend too much time on division but study the examples." It is also surely unwise to include anything such as "that seems a terribly long-winded explanation of a simple operation and I fear it will be as clear to you as mud." Furthermore, the student is recommended to memorise a good many results that can be so readily deduced, such as the signs of the trigonometrical ratios in the four quadrants, that it seems absurd to burden one's memory with them.

Despite the fact that virtually no previous acquaintance with mathematics is assumed, the author contrives to cover a substantial amount of ground in arithmetic, algebra, geometry, analytical geometry, differential and integral calculus. Some of the chapters, such as those on matrix algebra and determinantal manipulation, go deeper than others; in fact, as far as a mention of the Kronecker delta.

Though a good deal of the exhortation may be superfluous much of the advice proffered, such as having a dictionary at hand to check the meaning of words, will certainly be of benefit to the beginner. Misprints are comparatively few, but the statement, on page 26, "Look at your watch. Suppose it is a quarter past twelve. You know that the hour hand is then at 12 and the minute hand is at 3" needs amending. Portraits of six mathematicians from Archimedes to Einstein enliven the text.

Any book destined to promote a wider study of mathematics is more than welcome at this time. The usefulness of this book would almost certainly be extended by condensing some of its more elementary sections so that the approach to the high hills was not made along quite such gentle slopes. It might then be possible to reduce its cost which seems unduly high for a work of this kind.

★ ★ ★

NEW BOOKS

Modern Wiring Practice. By W. E. STEWARD. Third edition. *George Newnes, Limited, Tower House, Southampton-street, London, W.C.2.* (25*s.*)

This work has been revised to cover the thirteenth edition of the I.E.E. wiring regulations. It describes the distribution of supplies in buildings, the planning of sub-circuits, and such items as fittings and accessories. A survey is given of installation methods, and then chapters are devoted to the use of metal conduit, lead-sheathed cables and the like. The final chapter deals with the testing and inspection of installations.

Pump Selection and Application. By TYLER G. HICKS. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (8.50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (64*s.*)

After describing the different types of pump now available, the author goes on to consider operating conditions, including liquids to be handled and pipework, and then the various applications of pumps in different fields of industry. Included in the last-mentioned category are such industries as power plant, nuclear energy, food production and marine services.

Tables Numériques Universelles. By MARCEL BOLL. *Dunod, 92 Rue Bonaparte, Paris 6e, France.* (5,800 francs.)

This comprehensive set of tables is divided into six sections: arithmetic and algebra, trigonometry, exponentials, probabilities, complex numbers, and units and constants. It includes tables of single and double entry, about one-third of which are new. The number of significant figures is generally sufficient for practical needs and the tabular intervals usually permit of linear interpolation, although no differences are tabulated. Some 122 graphs are provided, on a large enough scale to enable numerical values to be read off. Other numerical data include mathematical constants, roots of equations, sums of series, and definite integrals. Explanations are clear and concise. The twenty-page supplement added to this revised second edition still further increases the publication's usefulness.

ATMOSPHERIC POLLUTION FROM POWER STATIONS

The erection of the large power stations, which have been a consequence of the rapid development of electricity supply in this country, have meant the combustion of more than 2,000 tons of coal per day on one site; and the emission into the atmosphere of varying amounts of sulphur oxides and gritty matter. How to avoid any undesirable effects of such emissions has been a matter for considerable study and experiment an account of which was given in four papers read before the Institute of Fuel on March 27 last.

In the first of these papers,* W. D. Jarvis and L. G. Austin described the results of measurements that had been made of the monthly amounts of pollution at observing points round a number of modern power stations with high chimneys and efficient grit arresters. These showed that the rate of dust deposition in the neighbourhood of the station bore no relationship to the amount of coal consumed, and that the increases in the average level of dust deposition, which occurred when modern stations had been put into operation, were less than the casual errors observed in the deposit gauge results. The effect of power station emissions on the average sulphur dioxide concentration at ground level, within a two-mile radius of the power station, was masked by many variables, but the maximum contribution was believed to be less than 0·2 milligram of sulphur trioxide per 100 square centimetres per day.

G. England, C. J. Crawshaw and H. J. Fortune† gave an account of a survey into dust deposition in the neighbourhood of the 120 MW station at Little Barford, where four 300,000 lb. pulverised-fuel boilers, equipped with electrostatic precipitators, discharged into two 275 ft. chimneys. The station was situated in flat countryside and it was found that the bulk of the dust emitted from the bituminous coal did not fall within 2¼ miles. Further afield, the effects were hardly detectable by deposit gauges. Relatively close to the station, the measurements of dust deposition were comparable with normal rates in a rural area. In fact, the greater proportion of the deposits collected came from other sources than the power station and frequently contained appreciable amounts of soil.

The deposition of dust at Little Barford was measured by standard equipment the performance of which was dealt with by Mr. D. H. Lucas.‡ As a result of experiments, it was found that a deposit gauge at ground level collected far more dust than one 4 ft. above the ground. He concluded that much of this additional catch was dust re-entrained from the ground and was therefore "spurious." Experiments had also shown that a standard gauge caught, on an average, twice as much dust when the bowl was kept wet as it did normally. Microscopic examination indicated that only one quarter of the dust collected originated at the power station.

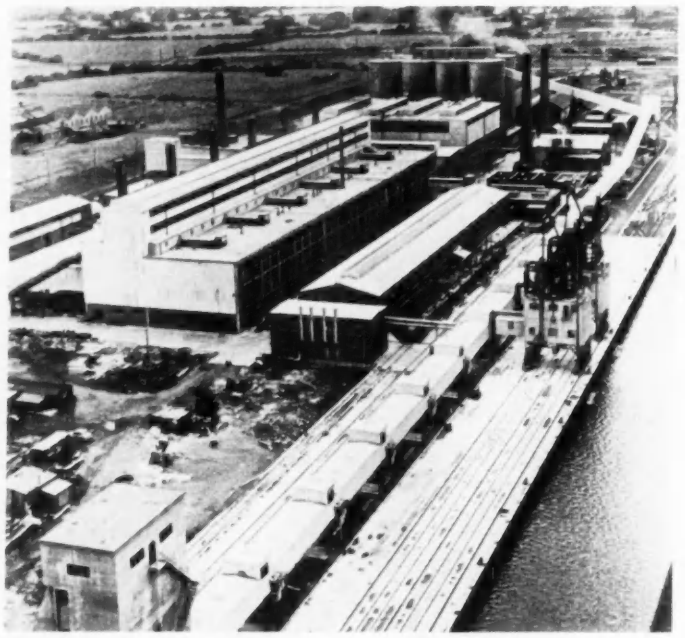
The subjects of the fourth paper were an automatic recorder and portable meter which had been devised by W. G. Cummings and M. W. Redfearn.§ These had been designed especially for atmospheric pollution work and both were sensitive to one part of sulphur dioxide in 100 million parts of air over the range from 0 to 50 p.p.h.m. The instruments had proved satisfactory during long periods of operation in the field and their use for atmospheric pollution work permitted a more realistic assessment of the amount of sulphur dioxide pollution than the conventional lead peroxide candles and daily volumetric estimations.

* W. D. Jarvis and L. G. Austin: "Routine Surveys of Atmospheric Pollution by Dust and Sulphur Dioxide Around the Power Stations of the Central Electricity Authority."

† G. England, C. J. Crawshaw and H. J. Fortune: "A Survey of Dust Deposition in the Neighbourhood of a Power Station."

‡ D. H. Lucas: "Certain Aspects of the Deposition of Dust."

§ W. G. Cummings and M. W. Redfearn: "Instruments for Measuring Small Quantities of Sulphur Dioxide in the Atmosphere."



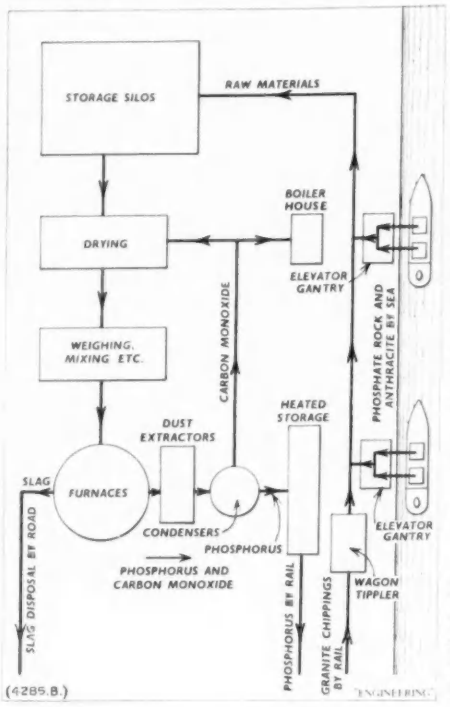


Fig. 1 (above) The works at Portishead for the production of phosphorus has an output of 40 million lb. a year. Sea-borne materials are unloaded pneumatically. Fig. 2 (right) The process lends itself to flow-line methods under semi-automatic electrical control. Carbon monoxide is one of the products and is used as fuel for the dryers and for the steam boilers.

ELECTRICAL PLANT IN PHOSPHORUS PRODUCTION

The process almost invariably used to-day for the industrial production of phosphorus consists, essentially, of the mixing of calcium phosphate with silica and carbon in an electric furnace. At high temperatures, the silica displaces phosphoric oxide and forms calcium silicate which is run off as liquid slag. The oxide is reduced by the carbon and the resultant phosphorus vapour and carbon monoxide are then passed over to a condenser, where they are separated. At the Portishead factory of Albright and Wilson, Limited, (Fig. 1) six furnaces are installed. From the simplified flow diagram (Fig. 2) it will be seen that the carbon monoxide extracted in the condensers is used as a fuel in the drying plant and boiler house.

ELECTRICAL SUPPLIES

The whole of the main switchgear controlling the electrical supplies to the factory is housed in a single-storey, brick-built substation. This building is divided into two main sections, housing the high-voltage and low-voltage switchgear respectively, with two small annexes for the battery and metering equipments. Almost all the electrical gear and most of the motors were supplied by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

The incoming supply from the South Western Electricity Board is stepped down to 11 kV, at which voltage it is controlled by duplicate busbar metalclad switchgear having a breaking capacity of 350 MVA. This high-voltage switchboard consists of 17 panels comprising three 15 MVA incoming supply units, six 8 MVA units controlling the feeders to the furnace transformers, four 4 MVA units controlling the primary supplies to the auxiliary transformers, and four bus-section units. Fireproof segregating walls are built between the front and rear bus-section switches on each section so that, in effect, the board is divided into three parts.

A panel carrying an indicating mimic diagram of both the high-voltage and low-voltage switchboards is mounted on the wall of the low-voltage substation, the connections between this panel and the switchgear being made with 32 core, 50 volt, telephone type cable.

The three-panel switchboard housing the metering equipment associated with the furnaces and the auxiliary supply circuits is installed in a small annexe divided from the low-voltage substation by a fireproof, sliding door. A further annexe houses the 110 volt battery together with its control board.

INCOMING RAW MATERIALS

The principal raw materials used at the Portishead factory are phosphate rock and anthracite, which are brought to the plant by sea, and granite chippings, which are carried by rail.

Both the phosphate rock and the anthracite are in a form which makes them suitable for handling by pneumatic plant. Unloading of vessels is therefore carried out by means of two mobile elevator gantries carried on rails along the length of the quay. These elevators can operate simultaneously and independently, each being provided with suction pipes which are manoeuvred and lowered into the hold of a ship by means of winches mounted inside the gantry. The raw material is drawn up these pipes into a hopper on top of the gantry, whence it is deposited on a small conveyor belt which transfers it from the gantry to the main conveyor. This main belt, which runs parallel to the quayside, is completely enclosed except for a series of ports with which the small conveyors on the gantries register when unloading is in progress.

The two suction pumps which produce the vacuum necessary for raising the materials from the holds are installed in a pump house adjacent to the main conveyor; each pump is driven by a 330 h.p. 415 volt 585 r.p.m. G.E.C. slipring induction motor. Part of the installation is shown in Fig. 3. The elevators are connected

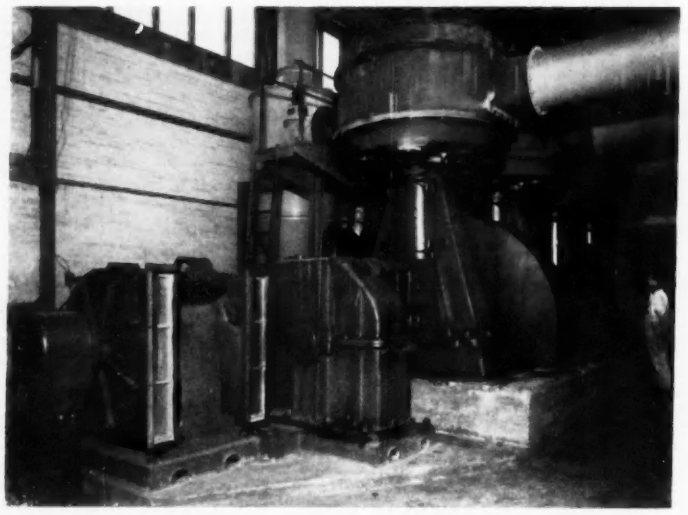


Fig. 3 The suction plant for handling the material from the incoming vessels is connected to a main running the length of the conveyor.

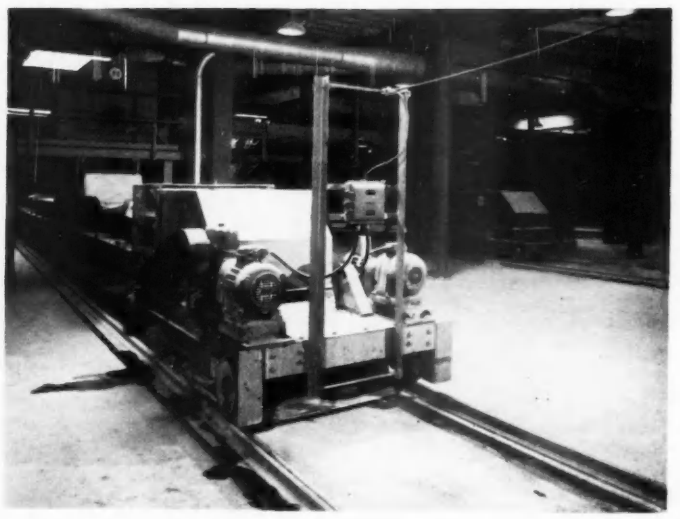


Fig. 4 Above the storage silos are three transfer belts which have carriages that can be stopped at the chosen storage space.

TWO PROCESS INDUSTRIES

to the pumps through pipes mounted beneath the main conveyor and running the length of the quay, the necessary couplings being mounted immediately below each of the ports in the conveyor enclosure.

The incoming granite chippings are unloaded by means of a wagon tippler on to the same main conveyor as the other raw materials. This conveyor leads up to the top of a bank of storage silos comprising eight circular bins, 100 ft. high, in which the rock is stored, the spaces between the bins being used to store the anthracite and the granite chippings. These silos have a total capacity of 24,000 tons.

On reaching the top of the silos, the material is deposited on to a transverse belt, which, in turn, conveys it to any selected one of three transfer belts. Each of these belts is mounted on a motor-driven, wheel-mounted carriage running on rails across the tops of the silos. The carriage may be stopped at registered positions such that the belt discharges into the top of the selected storage space, the cover of which opens automatically when the belt is correctly located. The carriages are shown in Fig. 4.

The unloading of the cargo vessels and the transference of the raw materials to the silos is carried out automatically. In a control room at the top of the silos is a control panel on which is a diagram showing which conveyor belts are in operation. The belt drives are electrically interlocked in sequence so that no belt can be started until the one before it is running. In an emergency, any section of the conveyor may be stopped by means of switches operated by hand-ropes which are installed along the full length of all the belts. If any particular belt is stopped, all those which come before it are automatically stopped at the same time, while those following it continue to run until they have cleared all the material they are carrying at that time.

MATERIAL PREPARATION

When the raw materials are removed from the storage silos for use, they are first of all dried in calciners, which, as previously stated, use as fuel the waste gases extracted in the condensers. The materials are then automatically weighed and mixed, and the mix is carried, by belt conveyors, to hoppers at the top of the furnace house whence it is fed, by gravity, into the furnaces.

In the furnace house there is a bank of six electric reduction furnaces, each capable of a maximum loading of 7,500 kW. In most respects, the design of the furnaces follows standard practice. The electrodes pass through the roof. Each furnace is supplied from a pair of 4,140 kVA, 3 phase, furnace transformers, installed in a separate brick-walled enclosure at the back of the furnace platform.

The delta-connected primary winding of each transformer is supplied at 11 kV from the high-voltage switchboard in the works substation, while the secondary winding is connected in star to give an output of 7,300 amperes at 180 volts no-load. Secondary voltages ranging from 100 volts to 230 volts can be obtained by means of two off-circuit tapping switches, one providing coarse and the other fine adjustment. The tapping switches are interlocked with the supply breakers.

The connections between the transformers and the furnace consist of tubular copper busbars, and the necessary supplies for metering and control equipment are provided by ring-type current-transformers threaded over these conductors. Control boards for each of the furnaces are situated at the back of the furnace platform. This control gear is designed so as to maintain a constant furnace load.

Periodically, each furnace is tapped and the slag is run out into covered ways where it is allowed to cool before being carted away by road. Any fumes that may be emitted while tapping is in progress are extracted by fans driven by 100 h.p., 960 r.p.m. G.E.C. slipring induction motors.

The mixture of phosphorus vapour and carbon monoxide, which is continuously drawn off from the top of the furnaces, passes through dust extractors to the condensers. Here the phosphorus is cooled to the liquid state while the carbon monoxide is allowed to pass through for use as fuel for the calciners and steam boilers. Transfer of the carbon monoxide from the condensers is effected by rotary boosters driven by 80 h.p., 1,460 r.p.m. slipring induction motors. Motors and other equipment throughout the factory are supplied from four auxiliary transformers, each of 1,000 kVA which step down the voltage to 415 volts. The windings are connected in delta-star and the neutral is brought out.

On leaving the condensers, the liquid phosphorus is piped to heated underground tanks, where it is stored in the molten state until it is pumped into specially constructed railway tank wagons for transportation to the factory at Kirby. Here it is converted to phosphoric acid and sodium tripolyphosphate. The latter is a compound which is incorporated in non-soapy detergents. The output of this latter substance from the new plants will entirely replace imports, which in 1953 amounted to over £2 million. The output of phosphorus from Portishead will be 40 million lb. a year—an amount greater than the total production of the United Kingdom before the works were commissioned.

Fig. 5 Three beet slicing machines feed each of the diffusion drums, two of them having variable speeds to allow for peak loads.

BEET SUGAR PRODUCTION

The Mallow Factory of the Irish Sugar Company in County Cork is equipped with diffusion drums for extracting the sugar from the beet as developed by the " Raffinerie Tirlemontoise " in Belgium. The " R.T. " method of extraction is of comparatively recent design and permits a continuous diffusion process in place of the old batch method using a battery of cells. The R.T. installation requires variable speed drives for the rotating drums and the beet slicers, with automatic control of speed to ensure a constant flow of slices to the drums. The numerous alternating-current motors driving conveyors and pumps are connected for sequence control. The control equipment and the motors were supplied by the English Electric Company, Limited, Marconi House, Strand, London, W.C.2.

Reference to the diagrammatic representation of the R.T. installation at Mallow will help to explain the basic sequence of events (Fig. 6).

The beet is brought to the factory by road and rail, and on entering the grounds each truck load is weighed and sampled. High-pressure water is used to unload the trucks and wagons and convey the beet into the factory where it is washed and then elevated to hoppers over the slicing machines. At this stage the beet enters the diffusion plant shown on the diagram. There are two R.T. drums at Mallow, each supplied with beet from a set of three slicing machines. The first slicer of each group is driven by an alternating-current motor and runs at a constant speed. This slicer normally takes base load. The remaining slicers are driven by variable-speed direct-current motors, rated at 45 h.p., 1,500 r.p.m., each supplied from a 440 volt generator, giving speed variation by Ward Leonard control. Normally, only one variable-speed slicer in each production line will be running at a time and its speed is controlled automatically to ensure that a constant quantity of beet slices is fed into each drum.

The maximum rate of feed for each drum is 55 tons per hour, but the actual value required is maintained by the use of an automatic weighing device (" Weightometer ") in the conveyor immediately following the slicers. This device provides an electric signal controlling a motorised rheostat in the generator field.

The cutting blades of the disc-type slicing

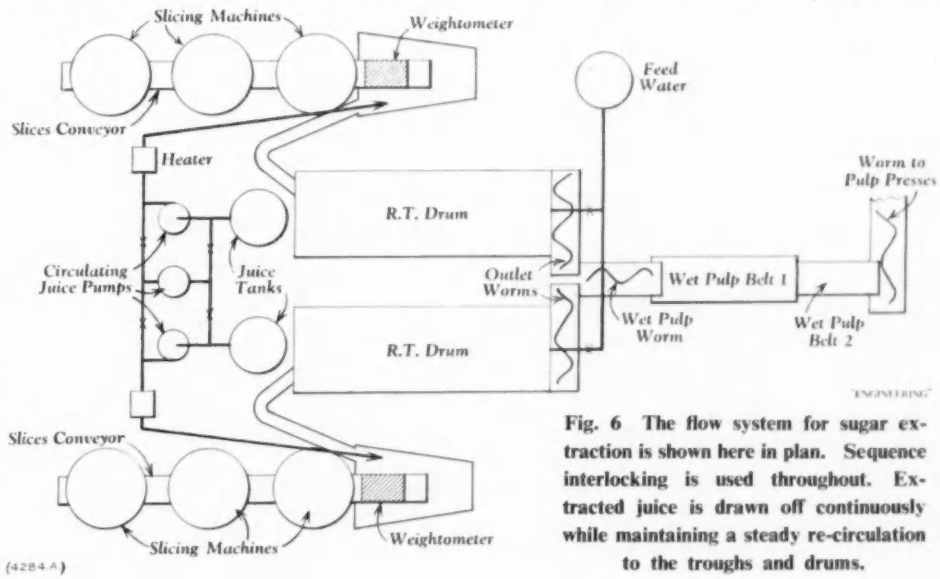


Fig. 6 The flow system for sugar extraction is shown here in plan. Sequence interlocking is used throughout. Extracted juice is drawn off continuously while maintaining a steady re-circulation to the troughs and drums.

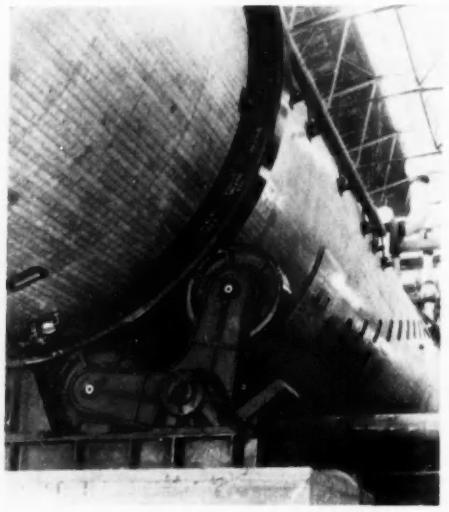


Fig. 7 (left) In the rotating drums, water passes over the sliced beet and extracts the juice. A loaded drum weighs about 320 tons.

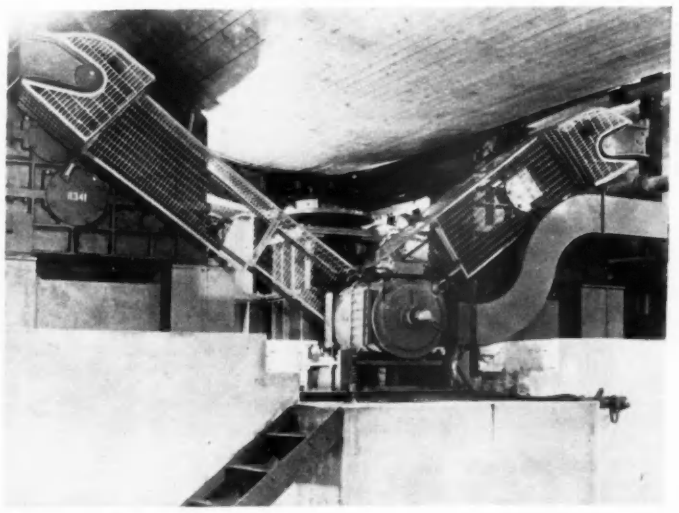


Fig. 8 (right) A variable-speed motor drives the drum at speeds between 20 and 25 r.p.m. through a fluid coupling and V-belts.

machines require regular attention to ensure maximum efficiency, the intervals depending on circumstances. To carry this out each slicer is stopped and the cutting blades cleaned, while they are inched in reverse. Inching on the direct-current drive is achieved by the application of fixed voltage of low value and reverse potential across the field of the appropriate generator. At less frequent intervals the cutter blades are completely removed and sharpened. The third cutter is started and switched to automatic control while one of the other machines is receiving attention of this kind.

After cutting, the beet slices fall on to the conveyor incorporating the "Weightometer," and then into a steel trough. In this trough the slices are mixed with heated juice re-circulating from the R.T. drum, and the mixture is fed into one end of the drum. The R.T. drum, weighing approximately 320 tons fully laden, runs on trunnion wheels. Near the end into which the slices are introduced a circumferential crown wheel, which is integral with one of the two tyres on which the drum is supported, is driven by two pinions each driven through gearing, a fluid coupling and a V-belt by a single variable-speed motor identical to those driving the slicing machines. When handling its full capacity, the R.T. drum rotates at a speed between 20 and 25 revolutions per hour depending on certain process factors.

As the beet slices and re-circulated juice enter the drum at one end, heated water is fed in at the other. With the aid of screens mounted inside, the rotation of the drum causes the slices to move down its length against the flow of feed water. The feed water extracts the sugar from the beet slices and leaves the drum, as juice, at the end into which the slices are fed.

The slices with the sugar extracted, known as exhaust pulp, are discharged from the other end and taken by belt and worm conveyors to the pulp presses. This pulp is used as cattle fodder both in its moist state, when it can be made into silage, and also when dried and stored in bags.

The juice discharges into a tank, from which the bulk is re-circulated in the manner already described and the remainder is pumped into the factory for processing in preparation for the manufacture of sugar crystals.

The six direct-current motors driving the slicers and R.T. drums are all force ventilated, air being provided by centrifugal fans fitted with viscous filters. After passing through the motor frame the air exhausts to atmosphere through sheet steel louvres which close under their own weight when the motor is stationary and the air shut off. This type of enclosure was deemed necessary in view of the generally moist sticky atmosphere which prevails in a beet-sugar factory.

The six generators are grouped to form two motor-generator sets, each with a squirrel-cage driving motor and constant voltage exciter. As the motor-generator sets are situated in the same building as the R.T. installation, all the component machines are force ventilated in a similar way to the driving motors.

The control equipment forms a composite board which is placed on the gallery overlooking the diffusion plant. A mimic diagram is provided for all the motors associated with the diffusion plant. Automatic contactor-type starters are used throughout for the alternating-current motors, with push buttons both locally and on the main control board. Sequence interlocking ensures that, in the event of a shut down, all motors prior to the fault in the line of production are stopped, whilst all subsequent motors continue to run.

MULTI-PURPOSE GAS-TURBINE RATED AT 2,000 KW

DISTILLATE-OIL OR NATURAL-GAS FUEL

The smallest member of the family of gas turbines made by the English Electric Company, Limited, Cambridge-road, Whetstone, near Leicester—which range up to 20/25,000 kW—is rated at approximately 2,000 kW under the ambient conditions prevailing in the United Kingdom. Known as the EM27P, that is, the English Electric multi-purpose 2,700 h.p. production gas-turbine, it is now being made on a batch production basis, and short delivery periods can be offered for many applications. Among the orders already placed for EM27P engines are two gas turbo-alternator sets for operation in Casabe, Colombia, and Lutong, Sarawak, both for operation on natural gas. Other orders are in hand for several peak-load and base-load generating sets, as well as for a compressor-drive turbine. The fuels used are distillate oil, natural gas or refinery gas. One generating set on order will operate on Diesel oil when the gas supply fails.

The EM27P is designed for long life, reliability and rapid response to load changes, at the same time using relatively high turbine-inlet temperatures to achieve a reasonable efficiency and compact installation. The auxiliaries are simple, and the engine can be easily adapted to burn a variety of fuels. Because of its light weight and small size, the machine is particularly suitable for mobile or stationary packaged power plants. No cooling water is required, and the unit can be made independent of any external source of power for starting. Designs are available for complete 2,000 kW generating sets mounted on skids, or on road or rail vehicles. The overall length of the road version of this mobile generating plant, which is complete with switchgear and auxiliaries, measures only 40 ft.

The EM27P is an open-cycle two-shaft gas-turbine, in which the high-pressure turbine drives the compressor and the low-pressure turbine delivers useful power. Aerodynamically the power turbine and charging turbine form one assembly, and are contra-rotating. Both turbines are two-stage units with cooled discs and stator rings. The compressor consists of a six-stage axial-flow assembly followed by a single centrifugal stage, and has a pressure ratio of 4·8 to 1 with a mass flow of 42·5 lb. per second.

Two versions of the gas-turbine are available. Where fuel cost is not of prime importance, the turbine is normally supplied without a heat exchanger, exhausting either direct to atmosphere or through a waste-heat boiler or some other form of exhaust-heat recuperator. A very compact plate-type all-welded heat exchanger is however, available as an extra to the engine and, as shown in the line drawing below, forms an integral part of the unit when it is mounted in position. The heat exchanger increases the efficiency by some 30 per cent. at the expense of a slight drop in power output caused by the back pressure set up by the heat-exchanger passages. The addition of the heat exchanger does not materially increase either the overall length or height of the engine, which are 8 ft. 6 in. and 11 ft. 6 in., respectively.

In order to obtain optimum performance from the gas-turbine under all operating conditions, three variants of the engine are marketed. For use in cold climates the engine is "matched" for operation at 0 deg. C.; that is to say, the turbine-blade heights are adjusted so that the relative sizes of the power turbine, charging (or compressor-driving) turbine and compressor are matched to give optimum performance at 0 deg. C. For temperate climates—the standard engine—the matching temperature is 15 deg. C., and for tropical climates 30 deg. C. The rating of the engine for these three conditions is given below:—

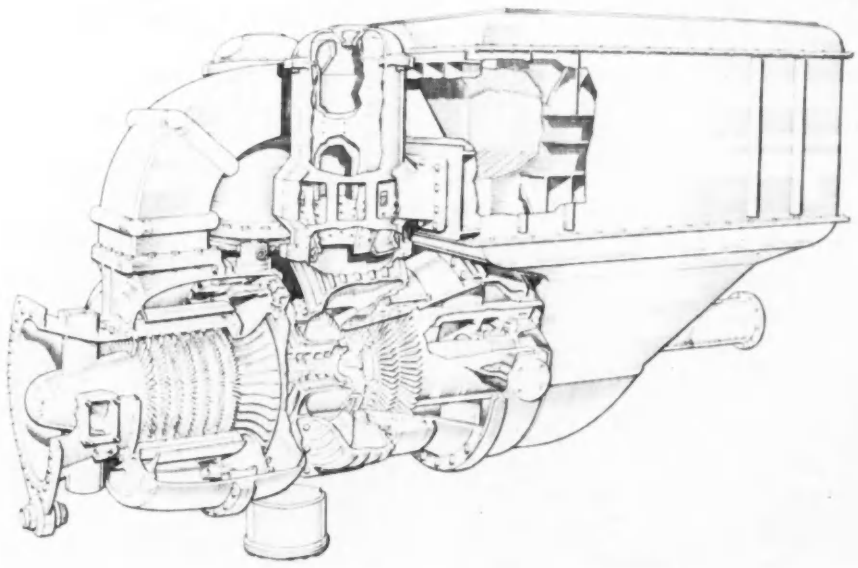
	With heat exchanger	Without heat exchanger
Matched at and operating at 0 deg. C.		
Full-load rating, h.p.	3,060	3,290
Efficiency, per cent.	25·37	19·28
Matched at and operating at 15 deg. C.		
Full-load rating, h.p.	2,750	2,957
Efficiency, per cent.	23·85	18·45
Matched at and operating at 30 deg. C.		
Full-load rating, h.p.	2,390	2,575
Efficiency, per cent.	22·71	17·54

The full-load turbine inlet temperature is 777 deg. C.; although this temperature is relatively high in industrial gas-turbine practice, the mechanical construction of the engine is such that starting, and load changing, can be carried out extremely rapidly without serious thermal stresses being set up in any of the component parts. For example, the engine without heat exchanger can be started from cold and run up to full load in 3½ minutes. The corresponding time for the engine with heat exchanger is slightly longer because of the thermal inertia of the heat-exchanger unit.

All the turbine outer casings are cylindrical in form with no horizontal joints, so that thermal expansion is equal in all directions and no distortion occurs, as may be encountered with casings with a heavy horizontal flange. Thus, turbine blade-tip clearances are closely maintained whatever the load on the unit, or the rate of change of load, may be. Moreover, a controlled air-cooling system is built into the engine, so that air bled from the compressor cools the outer casings, bearing housings, rotor faces, roots of the charging turbine blades, as well as being used to pack the various glands. Further protection for the casings, bearing housings, etc., is provided by internally-secured lagging mattresses of Refrasil (vitreous silica fibre) which line the inside faces of the turbine-inlet ducts, turbine - inlet casings, power-turbine diffuser, and the spoked turbine-exhaust casing. The gas ducts themselve are thin-walled fabrications of heat-resisting material which fit inside the internally-lagged outer casings. These "liners" are free to expand internally and carry only the temperature stresses; the pressure stresses are carried by the outer casings. When the turbine unit is assembled, the outer casings form a rigid unit and are supported at three points by rubber-bonded bushes mounted on trunnions. Thus, the alignment of the rotors inside the casings does not depend on the bedplate or external stools.

The components of the main turbine assembly are pre-machined and spigoted. The initial assembly is carried out at the manufacturer's works, and the engine is shipped complete, unless there are difficulties in handling the 7½ ton basic turbine unit at site. In such a case, the engine is shipped in convenient sub-assemblies which are readily bolted together, all the major flanges being spigoted for ease of assembly and to maintain the correct alignment of the shafts.

The EM27P industrial gas-turbine, as shown here without a heat exchanger, develops 2,957 b.h.p. with an efficiency of 18·45 per cent. With heat exchanger, the full-load output is 2,750 b.h.p. with 23·85 per cent. efficiency. The base dimensions are 8 ft. 6 in. by 8 ft. 2 in.



Cut-away view of the gas-turbine with heat exchanger fitted.

For further ease in erection, the turbine is normally supplied complete with a fabricated bedplate, which forms the main lubricating-oil sump tank. Only rudimentary foundation preparations are required before placing this bedplate in position. The shaft connecting the turbine and the driven unit incorporates patented flexible-disc couplings at either end of a short cardan shaft. This shaft is capable of taking misalignments of up to ¼ in. between the turbine coupling and the coupling of the driven unit when running at full load.

The auxiliaries required for the gas-turbine are simple and can be varied to suit local requirements. For example, the engine can be started from an alternating-current supply, or where a self-contained unit is required, from a suitably rated battery. The starting sequence in either case is automatic and controlled by a single push-button mounted on the turbine driving panel, full interlocking and protection being provided to guard against dangerous conditions developing in the plant. Ignition is by a torch igniter, using propane for oil-fired engines, or the engine-fuel supply for gas-fired engines. The propane stream is lit by a high-energy spark.

The lubricating-oil system incorporates a cooler which can either be of the shell-and-tube type, or where cooling water is scarce, a motor-driven fan-cooled radiator type. The cooled oil temperature, that is the temperature of the oil entering the plant, is automatically controlled to the desired level by a thermostat valve, which controls the flow of oil through the cooler and the cooler by-pass. Full-flow filtration is provided in the oil system by Micronic Purolator oil filters, which are easily cleaned and are both cheap in first cost and effective in operation. A larger size of this same type of filter element is normally specified for the main air-intake filters for the turbine, where such filters are called for through the degree of pollution of the ambient air at site.

Once on load, the turbine is fully safeguarded by a comprehensive protection system, which guards against low lubricating-oil pressure, high lubricating-oil temperature, high turbine-inlet temperature, high exhaust temperature, overspeed, combustion-chamber flame failure, etc. The turbine-inlet temperature control will override the governor should the turbine-inlet temperature rise above the specified limit, and cut down the fuel supply until a safe temperature is once more attained.

As mentioned, the engine has been designed to operate continuously for very long periods without major replacements. It is advisable, however, to replace the first stage of charging (or compressor-driving) turbine-rotor blades after 40,000 hours running at full load. Any proportion of the engine running time spent at powers less than full load very considerably increases the life of these blades. Conversely, overload running will naturally reduce the period after which the first stage of charging turbine blades should be replaced.

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BETTER PENCILS

A new development in pencil production is claimed by L. and C. Hardmuth (Gt. Britain) Limited, Chard, Somerset. The range is known as the Koh-I-Noor "Draughtsman Superweld." The lead is bonded to the wood which gives added reinforcement thus giving the pencil a longer life as it is stated they will not break when dropped or sharpened. Dense graphite deposits ensure the best possible prints even of the finest line by any method of reproduction. Distinctive colour tips provide easy identification for each grade.

ELECTRICITY UNDER CONTROL

HEAT, LIGHT AND POWER ON SHOW

The sixth Electrical Engineers Exhibition at Earl's Court, London, is yet another example of the growing popularity of the "specialist" display. Once again the size has been enlarged, and this year the whole of the first floor has been included. As mentioned in our Survey Note last week, a feature of this year's exhibition is the educational stand, a feature in which 27 bodies are taking part. This again demonstrates the very real feeling existing in industry of the need to attract recruits now, so that the ranks may be filled later, as the demand increases.

With the increased size and number of participants, the scope of the exhibition has been widened. For example, there are three models

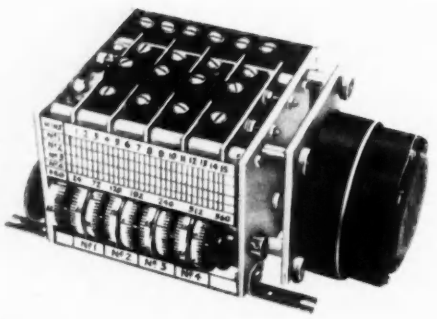


Fig. 1 Eight separate circuits can be controlled by this timer, and the sequence can be repeated.

of nuclear power stations; those for Berkeley and Bradwell being shown by the Central Electricity Authority on the Educational stand, and that for the South of Scotland on the General Electric Company's stand.

One of the first uses of electricity was for lighting; it is therefore appropriate that lighting still forms a large part of the exhibition. Apart from the 4,750 watt mercury lamp (made by Hackbridge and Hewittic, Limited, Walton-on-Thames) which, suspended 100 ft. from the floor, lights the whole 330,000 sq. ft. of the exhibition, there are many individual displays. Mercury fluorescent lighting is typified by the new Osram 400 watt deluxe colour corrected lamp, which is being shown on the General Electric Company's stand. Other lamps displayed by that company include a range of integral sodium lamps introduced recently and described in ENGINEERING. The A.E.I. Lamp and Lighting Company, Limited, Crown House, Aldwych, London, W.C.2, are showing their range of Mazda industrial shop and flood lighting display equipment, together with fittings designed for architectural use. There too, there is a new fluorescent lamp fitting which is flame-proof and can be re-lamped from one end.

Lighting plays a large part on the stand of Crompton Parkinson, Limited, Chelmsford, Essex. Both industrial and commercial fluorescent fittings of the new series will be included, and among them the "Storelite" fluorescent fitting. This is shown for the first time, and is specially designed for shop and store lighting. It is a louvred fitting suitable for use with three 5 ft. fluorescent tubes. Side panels can be either translucent plastic or enamelled metal. Also to be shown for the first time is the new flush-mounting frame designed to enable many of the standard fittings to be recessed in the ceilings.

A dustproof fluorescent reflector lamp is among the items shown by Philips Electrical, Limited, Century House, Shaftesbury Avenue, London, W.C.2, together with a new 8 ft. fluorescent lamp rated at 125 watts, and a new range of commercial 2 ft. fluorescent fittings. Colour-corrected mercury lamps up to 1,000 watts, infra-red heaters, ultra-violet tubes for air and liquid sterilisation, together with additions to the range of tungsten reflector lamps, make up the display.

Fluorescent lights also form a range of equipment made by Holophane Limited, Elverton-street, London, S.W.1. These embody a method of prismatic light control suitable for a wide range of commercial lighting applications. Light distribution and luminance control of the fittings are achieved by the use of injection-moulded clear plastic dished panels carrying a pattern of shallow cones which act as optical louvres, directing the light downwards, yet having low luminance when viewed obliquely. In this way brightness discomfort is eliminated. A comprehensive range of prismatic units is also displayed for commercial buildings and for industry.

AUTOMATIC CONTROL

Of all equipment, electrical apparatus probably lends itself best to automatic control, the basis of all automation. In particular, for many modern processes it is vital that there should be exact speed control of the driving motor. Almost as useful is the automatic control of operating sequences, whereby a whole process can be carried out without human intervention—rolling a bloom or assembling a valve can both be governed by modern commercial electronic equipment.

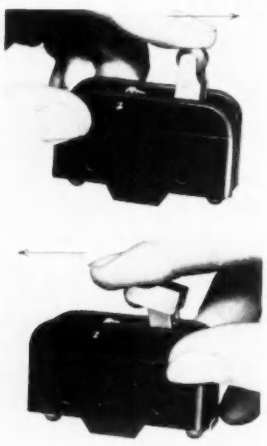


Fig. 2 The hinged roller will operate the micro-switch when the force is in one direction but not when it is in the other.

Motor control systems form the major part of the exhibits on the stand of Laurence, Scott and Electromotors, Limited, Norwich. These include the "Asrec" speed control system which is a standardised system for most normal requirements. It employs relay control and as, a general rule, a tachogenerator to provide a reference voltage. The steady-state accuracy obtained is of the order of $\pm$ 1 per cent. of the maximum speed, but a higher degree of accuracy is possible. The transient performance depends largely on the characteristics of the drive, typical figures being 2 seconds recovery time with 15 per cent. transient speed regulation.

The "Velonic" electronic control system is capable of regulating the speed of an N-S motor to within one or two r.p.m., with supply voltage and/or frequency variations of $\pm$ 10 per cent. and load variations from zero to full. The equipment is simple and compact, and the system is applicable to a wide variety of speed control requirements.

"Revcon" control is exhibited in operation on a model crane hoist motor. This provides stable speed control without friction or eddy current braking. It is suitable for crane, winch, hoist or similar devices. Low frequency injection to a standard 50 cycle induction motor for the purpose of obtaining stable crawl and inching speeds, and also for braking, is demonstrated in conjunction with a small frequency converter.

Other control gear exhibits include a multi-motor board with several typical standard starters. There will be in addition, a closed-air circuit induction regulator with a heat exchanger for the control of N-S variable-speed alternating-current motors of about 150 to 200 h.p. This design is tending to supersede oil immersed regulators and extends the range of air-cooled regulators available.

Motor control equipment is shown by Lancashire Dynamo Nevlin, Limited, St. Stephens House, Victoria-embankment, London, S.W.1, particularly with mercury arc rectifiers up to 2,000 kW output and adjustable speed drives up to 1,000 h.p. Other variable speed control gear includes the "Varionic" drive, and a transductor-operated Ward Leonard set, designed to give a speed range of 30 to 1. Fractional horse-power adjustable speed drives are shown by the associated company, Lancashire Dynamo Electronic Products Limited.

A static control system that can be built up from a range of standard units is the "Magistor" shown by Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester 17. The basic components of each unit are magnetic amplifiers, magnetic core devices and transistors, in none of which are there moving parts. Consequently, higher operating speeds can be achieved than with the use of conventional relays and contactors. The possibility of mechanical failure is greatly reduced, and routine maintenance eliminated. The Magistor photo-transistor relay has many uses in industry for such applications as counting, batching and sorting. The relay comprises two units of small dimensions, a lamp box and a receiver. Printed wiring is used in the circuits, and there are no thermionic valves, large photo-electric cells or high tension supplies required. The sizes of the two boxes are the same: height 7$\frac{5}{8}$ in., width 4$\frac{1}{8}$ in., depth 3$\frac{3}{8}$ in. The length of throw of the beam is 30 ft.

Speed control is also the feature of a feed for a grinding mill shown by Heenan and Froude, Limited, Worcester. The speed is automatically adjusted to suit particular conditions, thus obviating manual re-setting; and the rate of feed is controlled at the optimum value to ensure maximum production. A two-stage slow acceleration circuit is included for the initial charging of the mill, together with feed failure protection. It can be included on most types of feeder.

For the first time the firm are showing one of their new range of liquid-cooled couplings, the range of which will eventually extend to 1,000 h.p. These give infinitely variable speeds against constant torque loads down to zero

Fig. 3 To aid accessibility, the contactor assembly is mounted on the removable door.

Fig. 4 The air-blast 132 kV circuit-breaker has all phases operated from a single control unit.

speed. They are immune from adverse atmospheric conditions, as they are totally enclosed. Close control and speed regulation are easily obtained by the use of simple low-power electronic excitation equipment.

A repeated cycle of operations can be carried on indefinitely by the programme controller also exhibited by Heenan and Froude, Limited. By its use, virtually any number of operations can be planned in any required sequence. The equipment consists of an electronic frequency generator unit, which is used to produce tones of various frequencies. These tones are selected by push-buttons, the number used depending on the number of separate operations required in the sequence. The tones are recorded on a magnetic tape, and the recorder is connected to an electronic frequency selector unit, which identifies the various tones and operates the appropriate contactor to initiate the final motion or operation. With this system a library of recorded schedules can be stored for long periods if necessary. Alternatively, out-of-date operations can be erased and a new set recorded on the same tape. This equipment is shown controlling a variable speed drive in accordance with a pre-selected programme.

One of the two items most recently added to the range manufactured by Electrical Remote Control Company, Limited, Eastern Industrial Estate, Harlow New Town, Essex, is a high-voltage relay of the sensitive type, capable of withstanding up to 4,000 volts d.c. between the contacts and the coil. The relay will operate at 20 milliwatts d.c. or 3 VA. The maximum operating voltage is 250 volts d.c. or 1,000 volts a.c. and switching capacity is 5 amperes at 230 volts a.c.

EIGHT CIRCUIT TIMER

The other item is a timer (Fig. 1) for general purpose work, controlling up to eight electrical circuits. Each of the circuits is independently adjustable by the setting of a cam operating a change-over switch. The total length of the timing cycle is also continuously adjustable. External indication of the progress of timing is provided. Re-setting is automatic, within half a second of the end of the timing cycle or when the supply voltage is removed. The timer can also be arranged to repeat continuously a timing cycle with the automatic re-set on voltage failure only. Switching capacity of the changeover switches is 15 amperes at 230 volts a.c., when operating with a non-inductive load, or approximately 1 h.p. at the same voltage. Standard timing ranges are from 0·12 second up to 28 days. The timer consists essentially of a miniature motor with a gear train, electromagnetic clutch and automatic re-set mechanism, driving a camshaft with up to eight adjustable cams and a progress of timing indicator.

A calibrated relay for the control of voltage, current or speed is one of the items exhibited by Smiths Industrial Instruments, Limited, Chronos Works, North Circular-road, London, N.W.2. It consists of a permanent magnet and coil system similar to that used in a loudspeaker, giving a very high efficiency of conversion from electrical energy to mechanical force. The precision is achieved by a magnetic lock which can be adjusted accurately to a predetermined value. This lock opposes the motion of the moving coil until the force developed by the coil exceeds the magnetic locking force, when the contacts close with a snap action, resulting in an immediate rise of contact pressure in excess of 20 grams. Under static conditions closure occurs within ± 1 per cent. of the setting value. The relay consumes between 20 and 30 milliwatts. The actual setting can be controlled externally, and the moving coil has a resistance sufficiently low for it to be used directly from instrument rectifiers.

STABILISATION

Voltage stabilisation is an essential part of accurate control of much equipment, and a range of stabilisers for laboratory or industrial use is being shown for the first time by Philips Electrical, Limited. The range has outputs from 300 VA to 6 kVA. In the smallest type, stabilisation is effected by two transformers connected in series, the first having an unsaturated and the second a saturated core. A capacitor is fitted to compensate for load variations. Models are available for 50 or 60 cycle working at 220 volts nominal input. The output is maintained within ± 1 per cent. for mains fluctuations from − 15 per cent. to + 10 per cent. The output voltages of the 1, 1·5, 2 and 5 kVA models are controlled by a transductor in series with part of the main transformer winding. Any variation in secondary voltage is eliminated by a bridge circuit and amplifier. If the secondary voltage rises above a certain level, a safety relay is brought into action to reduce it. The stabilisers are independent of frequency variation, and even relatively large fluctuations of power factor in the inductive range do not affect stabilisation. They are available for input voltages from 110 to 220 at 50 cycles, and variations in the mains voltage from − 15 per cent. to + 10 per cent., and in frequency of ± 3 per cent. are acceptable, for an output control within ± 0·2 per cent. of the nominal voltage.

Control items such as relays, timers and counters make up the display of Londex, Limited, 207 Anerley-road, S.E.20. Two very small relays have recently been introduced, with laminated iron chassis, capable of accommodating four change-over lever contacts or one 10 ampere mercury switch. Coil voltages are up to 250 volts a.c. Again with the object of producing items of small size, transistorised photoelectric equipment has been produced with a built-in meter to assist in the correct aligning of the light projector and the transistor receiver heads. For counting there are units that will take up to 4,000 pulses per second, operating on pulses of approximately one-fifth of a millisecond duration, with a similar interval between pulses. One version is made for batching purposes, and is capable of carrying out four batching operations per second. These instruments display their count on the faces of dekatron tubes, and cannot be read from any great distance. To overcome this, a special unit has been developed which provides a large numeral display.

More microswitches have been added to the range made by Burgess Products Company, Limited, Leicester, and seven new ones are being exhibited. In one range of these, the tripping point tolerance is only ± 0·005 in. Others include a plunger-actuated, metal-clad switch; a one-way impulse switch designed for the operation of solenoid valves; magnetic counters and the like (all the action being initiated by the depression of a plunger); an automatic door interlock switch and types fitted with actuating rollers that operate the switch when the driving force is in one direction only. The last is shown in Fig. 2.

A motor control centre is one of the exhibits on the stand of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. It has been developed to provide centralised control for a number of alternating-current motors or circuits. Essentially it consists of a cubicle which will accommodate a wide range of starters and switch fuses for operation up to 600 volts. The individual control units can be plugged into the cubicle, so that not only is maintenance simplified, but units of the same rating can easily be exchanged. Any number of cubicles may be coupled together to form a compact switchboard.

Switches and motor control gear make up the exhibits of J. A. Crabtree and Company, Limited, Lincoln Works, Walsall. Shock-proof flush-mounting switches for lighting circuits are supplemented by new units including 5 and 15 ampere 3 pin switched socket outlets for flush and surface mounting. All these are available

Fig. 5 (right) The diverter switches of the tap changer operate by a spring-loaded toggle mechanism.

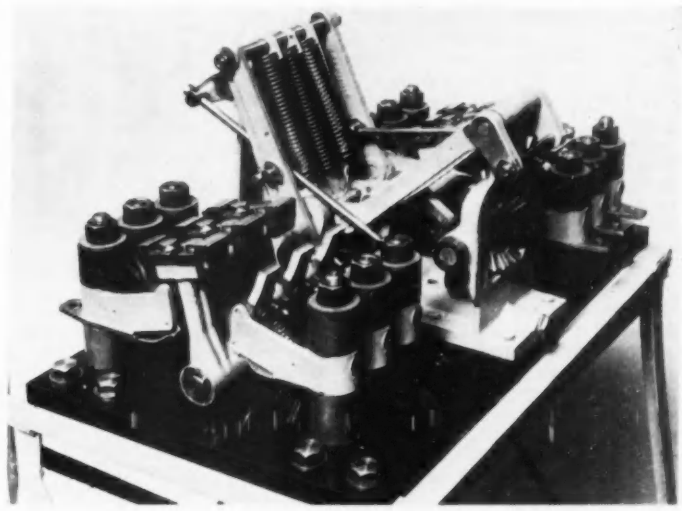
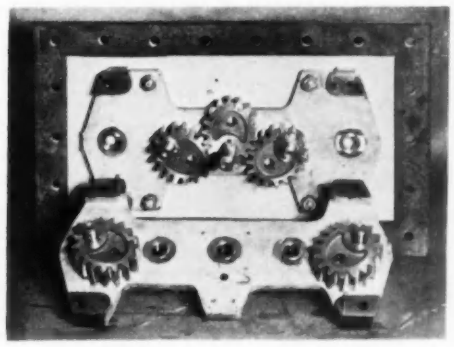


Fig. 6 (below) Elliptical gears in constant mesh are used to drive the selector switches of the tap changer.



in shockproof and in metal patterns. The motor control gear includes a new range of flameproof remote control stations available with 1, 2 or 3 buttons, and limit switches for various types of operation.

Special-purpose control panels are the main items on the stand of G.W.B. Furnaces, Limited, Debdale Works, Dudley, Worcestershire, and examples illustrate the ease of access for maintenance which is possible with these panels. Contactors range from 10 to 1,400 amperes capacity and isolators up to the same figure. Other examples of contactor control are a panel for a steel rolling mill conveyor system and equipment for a main motor with auxiliary drives in the tube manufacturing industry.

MOTORS AND GENERATORS

Once again, motors play a prominent part in the exhibition, although they do not, as last year, make the theme. New exhibits by Brook Motors Limited, Empress Works, Huddersfield, include two starters, a single-phase power pack consisting of a motor-starter combination, designed for agricultural or small industrial use, and fractional horse-power motors and others from industrial ranges.

Lancashire Dynamo and Crypto, Limited, are displaying a motor insulated to class H (a rating which has not yet received official sanction, but which offers considerable savings in size and weight, working at a high ambient temperature) and also a self-regulating alternator, driven by a non-excited synchronous motor. Samples of special equipment include a set for school laboratory use and a drive incorporating a fluid coupling, brake and gearbox.

The range of industrial motors exhibited by Crompton Parkinson, Limited, includes the new models of the series 5. These are standard ventilated type squirrel-cage three-phase motors with powers ranging from 4 to 50 h.p. They employ Class E insulation, allowing them to operate at continuous maximum ratings with a temperature rise of 65 deg. C. This has enabled both size and weight to be reduced and the form of a protective enclosure to be made. The reduction in weight over the range that they supersede may be as much as 40 per cent.

A two-speed motor of unusual construction is among the items displayed by British Bronson, Limited, Stocklake, Aylesbury, Buckinghamshire. Known as the "Dynaplus" it is basically designed to serve as a power plant for machine tools. As such it is capable of withstanding up to 32 speed changes or reversals per minute. Both complete and sectional models are being shown. The fan for cooling the unit is driven by a separate motor, so that an ample supply of cooling air is maintained to the main windings during speed changes or reversals. A centrifugal switch is employed, which ensures that the main motor cannot start until the fan is supplying sufficient cooling air, and likewise if the fan motor should fail, the main motor is automatically switched off. The motor is designed to operate from a 3 phase supply and develops 1 h.p. at 720 r.p.m. and 4 h.p. at 2,800 r.p.m.

The "Newphase" alternator shown by Arthur Lyon and Company (Engineers), Limited, 6 Carlos-place, London, W.1, is a development from the standard Stamford alternator to produce a machine giving very exact regulation. An additional voltage control is incorporated, which converts it from a compensated machine to a closed-loop system with a positive voltage reference against which the output voltage can be compared. A cold-cathode discharge tube is utilised in the error detecting section as the non-linear element in a four-arm bridge. The output of this bridge is fed to the control winding of the magnetic amplifier, which forms the second stage of the circuit. The gain of this amplifier is in the region of 5,000 to 1. Finally, the magnetic amplifier output is rectified and the voltage so obtained is used to feed the control winding of a saturable reactor connected in the primary circuit of the voltage transformer. Any departure from the nominal voltage due to causes other than load change (which is attended to by the combination of voltage and current transformers incorporated in the standard machines), is automatically corrected to within close limits by this overriding control. With the change of excitation brought about by the change in load, full voltage recovery can be obtained in a time of 5 to 10 cycles only. Machines are available up to 9 kVA, and in both single and three-phase design.

DISTRIBUTION

The main exhibit by Brookhirst Switchgear, Limited, Chester, is a new design of cubicle switchboard laid out for flexibility and accessibility (Fig. 3). The pillar type cubicle units are fabricated from heavy-gauge sheet steel, each unit accommodating a top-mounted busbar chamber, vertical rising bars and tiers of contactor starting equipment of various types. Distribution gear can be included and items are interchangeable. One of the basic features of the design is the fact that the control gear is mounted on the inside of the compartment door, and so is automatically swung out for inspection. Lift-off door hinges are fitted, permitting a complete starter fitting to be removed for servicing or replacement. Plug-in type isolating contacts are employed for incoming and outgoing connections, thus dispensing with trailing cables. In addition to the normal electrical interlocks each cubicle door handle is mechanically interlocked with the contactor.

High voltage switchgear is displayed on the stand of Ferguson-Pailin Limited, Higher Openshaw, Manchester, 11. The main exhibits are a 33 kV 1,000 MVA indoor metal clad switch unit, and a 132 kV outdoor air blast circuit breaker. The switch unit incorporates such items as rapid fault clearance, integral earthing and positive interlocking; and has been tested on short circuit. The 132 kV circuit breaker, Fig. 4, is made up from three single-phase units, each consisting of a chassis with a solid-drawn air receiver built in, supporting three porcelain insulators. The main insulator supports three interrupters in trefoil formation, and contains the porcelain air inlet pipe which connects the interrupters to the blast valve. Of the two smaller insulators, the middle one constitutes the drive shaft for the isolator contact arm and the other supports the isolator fixed contact and line connection. The blast valves are mounted at the base of the air-filled tubes and are of aluminium alloy construction. All three are operated by a single control unit. The sequential isolator operates at high speed and incorporates fluid damping in its driving mechanism. The switch can be converted very simply to auto re-close. There is only one trip coil for the three phases, which gives a combination of low control power with high speed operation.

Fig. 7 Phase sequence can be checked by this pocket instrument which is safe up to 600 volts.

Fig. 8 A single coil forms the search head of the Asdet which detects the presence of tramp metal.

A new range of distribution fuseboards has been produced by the English Electric Company, Limited, Marconi House, Strand, London, W.C.2, and is shown on their stand. Known as the "Red Spot" range, they incorporate various safety features. All live metal inside the fuseboard is enclosed in insulation, and even with the fuse carriers removed no live metal is exposed. The fuse carriers and bases are so designed that it is stated to be impossible for live metal to be touched no matter how the carrier is held while being withdrawn or inserted. Each incoming cable socket is enclosed in an insulating housing, fitting snugly over the insulation of the incoming cable. The fuseboards incorporate the type "T" high rupturing capacity non-deteriorating cartridge fuse links covering the full range of sizes.

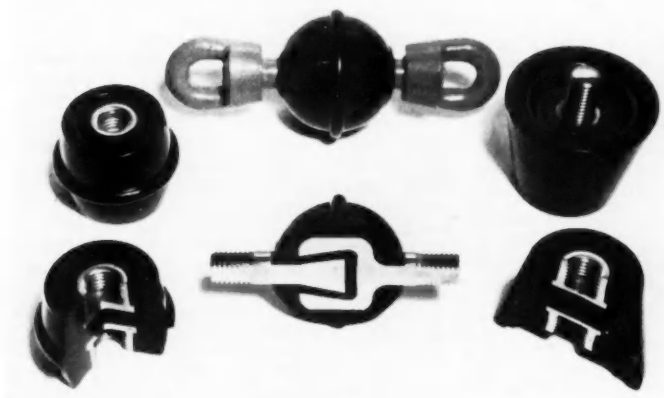
Tap-changer gear for transformer control is among the items shown by the Fuller Electrical and Manufacturing Company, Limited, Fulborne-road, London, E.17. An on-load tap-changer is exhibited as being typical of a complete range of high speed resistor tap-changers suitable for three-phase transformers with loadings from 200 to 800 amperes. Fully insulated tap-changers for 132 kV are also available. The model shown is for 33 kV delta windings with a nominal rating of 400 amperes. The diverter switches are of the toggle type and operate at high speed under the force of springs (Fig. 5). The selector switches are of the eccentrically-operated rotary type, and use an elliptical gear drive which is in continuous mesh. One of these gear units is shown separately for demonstration (Fig. 6).

Although Standard Telephones and Cables, Limited, Connaught House, Aldwych, London, W.C.2, have been making transformers for more than 50 years, this is the first occasion on which power transformers made by them have been exhibited. Present production is up to 50 kVA, and the range is being extended up to 1 MVA. There are both single-phase and three-phase types of "open," "potted," "C-core" and hermetically sealed constructions, and a representative selection of types and models is shown.

Among the many instruments displayed by Ferranti Limited, Hollinwood, Lancashire, is a loop impedance tester for phase to earth. Instead of working on the current injection principle, the tester momentarily puts a fault from line to earth, and is operated by the fault current. This method is thought to be superior to low-voltage testing. The fault current passes through a push-button making switch, two miniature circuit-breakers and a chosen shunt. The circuit-breakers interrupt the current in $1\frac{1}{2}$ cycles. If the loop impedance is low enough to permit the passage of a fault current greater than the fuse rating marked on the shunt selector switch, a cold-cathode valve is triggered and glows continuously until re-set. Thus a positive indication of the safety of the circuit is given as a result of an actual test. A voltmeter is incorporated in the instrument and can be used to check the polarity of the supply.

Fig. 9 (left) A busbar support frame made from Permali affords complete insulation.

Fig. 10 (below) Tufnol insulation can take considerable loads. The selection of mouldings shown are designed for 660 volts and two tons working load.



The clip-on ammeter has its latest development in a model designed for use on 11 kV cables such as are used on overhead lines. A hinged core current transformer is fitted at the end of a pole 4 ft. 6 in. long, made of tubular insulating material. The hinged core is opened and closed by pressing it against the overhead line. Connections from the secondary winding are brought inside the tube to a 3¼ in. dial ammeter mounted near the other end of the pole section. This instrument has five ranges, measuring up to 200 amperes.

A new core design is incorporated in a rural distribution transformer built by Ferranti Limited. The core consists of strips of low-loss grain-oriented steel wound into a coil, the overlapping joints being locked in position, giving it its name of the " Lock Wound Core." As the flux path follows the grain of the steel, and as the air gaps in the core structure are almost eliminated, the design gives lower iron losses and reduces magnetising current. A transformer with class H insulation is part of a special display showing the internal construction of the core and windings.

Among the many switchboard and portable measuring instruments shown by Measuring Instruments (Pullin), Limited, Electrin Works, Winchester-street, London, W.3, is a process controller being shown for the first time. This has been designed to provide an instantaneous reading of temperature, and by means of a pre-set indicator to actuate a warning system. The instrument has a modified 6 in. moving-coil indicating mechanism, fitted with an adjustable pointer, incorporating a photo-electric pick-up. The index pointer can be adjusted to monitor a process according to any reading over the entire scale. Output from the pick-up is fed to a magnetic amplifier which in turn operates a standard relay. The instrument is entirely self-contained, and is capable of direct switching up to 5 amperes at 250 volts. The differential switching accuracy is ± 2 per cent. of full scale deflection.

A portable instrument for indicating the phase sequence of a system is being shown by the English Electric Company, Limited, (Fig. 7). It is basically a simple induction motor with a conventional three-phase stator winding, and a rotor in the form of a pivoted light-alloy disc. When the leads are connected in the sequence red, yellow, blue, the disc revolves in a conventional anti-clockwise direction. Leads 3 ft. long are supplied with the instrument, and are fitted with strong insulated spring clips. The indicator, which is in a plastic case, need not be removed from its leather carrying case when in use. Rated at 50 to 600 volts at 20 to 400 cycles per second, the indicator can be left in circuit for half a minute at the higher voltage. Complete in its leather case, it weighs 14 ozs.

Among the instruments displayed by Crompton Parkinson, Limited, is a three-phase tachometer-generator equipment of the type recently introduced for industrial use. It comprises a rectifier type moving coil volt meter and a miniature three-phase alternator. The main advantages of a tachometer generator are that it has no brushes or sliding contacts to cause wear, and since the rectified three-phase voltage impulses overlap each other, the indicator is steady at comparatively low speeds.

The Asdet is an electronic device for detecting metals or metallic ores when mixed with non-metallic substances passing the detector head on a conveyor belt, Fig. 8. A single coil is used as the search head, and three valves only are employed. An adjustable-time delay relay is included in the equipment for signalling purposes. The head is not affected by temperature variations and can detect tramp metal at high speeds of passage up to 60 m.p.h. It is exhibited by the manufacturers, ASEA Electric Limited, Fulbone-road, London, E.17.

Infra-red heaters are prominent among the exhibits displayed by Dimplex Limited, Millbrook, Southampton. There are both domestic and commercial models. The domestic model is designed for a loading of 750 watts, and can be mounted by chain suspension or by conduit. It incorporates a narrow beam, chromium plated reflector to give localised heating in a defined area. It is suitable for siting over a sink or bath or other such situation. The commercial and industrial types also beam the heat in a sharply defined area. The loadings of the two models are 2½ kW and 4 kW; they are 3 ft. and 4 ft. long respectively. Other heaters operate by convection or by radiation, and several models are displayed.

Off-peak heating equipment and other low temperature radiant warming apparatus is displayed by Panelec (Great Britain), Limited, 21 Bloomsbury-street, London, W.C.1. The items include a model showing a general arrangement of the company's floor warming system to demonstrate the cable housing sections embedded in the floor screed, and the spring clips which attach the expanded metal heat diffuser to them. One of the advantages claimed for the system is ease of access to both the electrical supply cables and the heating cables, whether they are installed in walls, floors or ceilings. Similar systems slightly modified can be used to prevent " heave " in the floors of cold stores.

The use of electricity is closely connected with the production of the necessary materials for insulating conductors. Permali Limited, Bristol-road, Gloucester, are showing films demonstrating the construction of rotating machines, transformers and switchgear, and also some films of general interest from other manufacturers. Special emphasis is placed on the company's Permaglass glass-fibre reinforced laminates, and exhibits include end-shields, overhead line operating poles, air baffles, coil support rings, junction boxes and other equipment. A busbar support structure made entirely of Permali crowns the stand, Fig. 9. Among other exhibits are examples of Dialam laminated paper, fabric tubes and indoor and outdoor switchgear and transformer bushings suitable for voltages up to 69 kV.

Various forms of insulation are being exhibited by Tufnol Limited, Perry Bar, Birmingham, 22B. The material posseses good mechanical strength in addition to providing good high grade electrical insulation. It is now being used extensively on pipelines to counteract electrolytic action. Examples on show include bearing pads for pipes up to 7 ft. in diameter as well as samples of gaskets, washers and bolt-jackets for pipeline couplings. The range of moulded bell, ball and barrel insulators is suitable for working loads up to two tons and for voltages up to 660 volts, Fig. 10.

Another range of insulation is shown by the Micanite and Insulators Company, Limited, Blackhorse-lane, London, E.17, including the Micanite commutator end rings and Paxolin synthetic resin bonded transformer cylinders.

* * *

EARTH-ELECTRODE SYSTEMS

The increasing concentration of generating plant and, in this country, the practice of directly earthing the neutrals of the transformers on the 132 kV and 275 kV transmission systems, have resulted in the possibility of earth-fault currents reaching considerable values and consequently to high stresses being imposed on earth-electrodes. While in areas of low soil resistivity this problem gives rise to no great difficulty, in places where stations have been built on limestone, sand or peat the maximum earth-fault currents may reach 3,000 amperes. It is then essential that the earth system should be so designed that damage to life or plant by reason of high potentials, potential gradients and thermal or mechanical stresses is avoided.

As pointed out by Mr. J. D. Humphries in a paper* presented to the Institution of Electrical Engineers on March 27, an earth-electrode system to be satisfactory must not only meet these requirements when carrying normal power-frequency currents. It must also be capable of dealing with high-frequency currents due to lightning, and should be designed so that the impedance presented to these currents does not differ greatly from the power-frequency impedance. In the case of large stations, such as are dealt with in the paper, the inductance of the various interconnections may, however, be considerable. It is therefore essential that an appreciable proportion of the total dissipation conductance of an earth electrode system should be concentrated at the points most likely to be affected by surges.

An examination of the earthing system using an arbitrary number of quite small electrodes, such as is now commonly employed, has shown how unsatisfactory this may be when applied to large stations. In fact, the fault levels have now risen to a point where it is essential to plan the station earthing with nearly as much care as is devoted to the primary connections, in order to obtain adequate designs in the restricted space available on modern sites. Moreover, the measuring techniques used in the past have tended to give results which are not repeatable, owing to the low values of the resistance involved and the large areas to be covered.

* " Earth Electrode Systems for Large Electric Stations."

ATOMIC REVIEW

Complementary Angle

No doubt an element of competition between countries is entirely desirable, but there are times when co-operation may yield more profit. Particularly is this true in the field of atomic energy. Britain, for example, has needs and resources which complement rather than rival those of the United States. (A similar relationship may hold between Britain and Europe, but the position here is less clearly defined.) America has extensive technical and experimental resources, enriched fuels and plenty of time; Britain has practical experience on large stations, cheaper manufacturing facilities and the pressure of urgency. These points have often been made. Thus America's access to conventional energy supplies will make her independent of nuclear power for some years; meanwhile she can investigate a wide variety of reactor systems, assisted by considerable stocks of enriched uranium. Britain, compelled to supplement her limited coal resources, has been driven to solve at an early date the economic and engineering problems of building and operating large nuclear plants. Britain has also certain manufacturing advantages; hence the agreements between Alco and Humphreys and Glasgow (ENGINEERING, February 8, page 185, 1957), and between A.M.F. Atomics and Mitchell Engineering (ENGINEERING, April 13, page 220, 1956). Both Britain and the United States stand to benefit from an exchange of knowledge, services and products, and there can be little question that development in the two countries

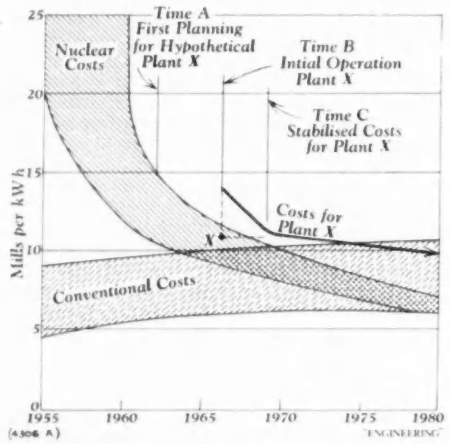


Fig. 1 Estimated costs of power from large nuclear and conventional plants going into service each year in the United States. Load factors of 70 to 80 per cent. are assumed.

will be closely associated. It follows that decisions must be taken, not in isolation, but in the context of complementary activities overseas. The American angle on the future of atomic energy has therefore a more than local interest.

American Long Term View

The future development of atomic energy in Britain has been treated at length in ENGINEERING. A paper has now been published summarising the American view, the substance of which is published below. It was prepared jointly by Mr. W. Kenneth Davis, Director, and Mr. Louis M. Roddis, Deputy Director, Division of Reactor Development, United States Atomic Energy Commission, and presented at the Fifth Atomic Energy in Industry Conference in Philadelphia, Pa., on March 14.

Cost of Nuclear Power

The cost levels expected to be achieved by large nuclear power plants going into service at various times during the next 25 years are shown in the descending shaded area in Fig. 1. A company considering whether its new plant should be nuclear-fuelled or fossil-fuelled is interested in the cost performance of the plant over its useful life, not just at the start.

In addition to estimates of power costs from large nuclear and conventional plants, shown in the shaded bands, Fig. 1 also illustrates the factors underlying a decision to build a hypothetical nuclear plant X. A given utility may be interested in authorising design and construction of the plant at time A. The plant will not actually come into operation until time B, three or four years later. As shown, initial costs of operation at time B will be high due to the special problems involved in start-up of nuclear reactors. It is expected that costs will stabilise at a lower level after two or three years of operation, that is at time C as shown on the chart. Presumably this cost was predicted with a fair degree of assurance before the project was authorised (time A). Such stabilised costs are given as a function of the times when the various plants come into initial operation. This is indicated by point X. Following achievement of stabilised costs at time C, there is likely to ensue a long-term slow decline in costs for plant X, as shown by the plant X line on the chart, due to lower nuclear fuel costs.

In considering the genealogy of nuclear power, the plants going into service during the years 1957 through 1959 may be said to belong to an experimental period during which there can be no hope of achieving costs competitive with modern conventionally fuelled plants in the United States. Costs achieved by these early plants may range from about 20 to as much as 50 mills per kilowatt-hour. (One mill is one-thousandth of a dollar and equivalent to about 0·09*d.* or roughly one-tenth of a penny.) The years 1960 to 1964 will bring the first generation of true industrial nuclear power plants.

As can be seen from Fig. 1, however, it is not expected that plants in the first generation will produce power at costs competitive in the United States with the most advanced conventionally fuelled plants. It is estimated that first generation nuclear plants, after their initial shakedown period, will achieve costs in the range of 10 to 13 mills per kilowatt-hour, at 1957 price levels. The cost of electricity from modern coal-fired plants are as low as 4½ mills in very low-cost fuel zones and range up to 9 mills in other areas. In 1964 the costs from new coal-fired plants may have changed slightly but should still be approximately in this range.

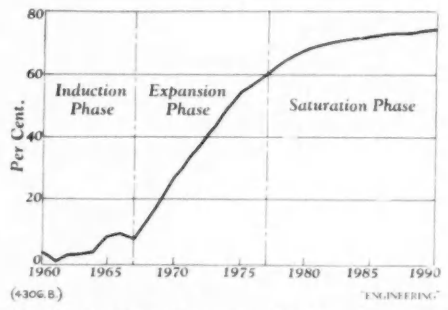


Fig. 2 Anticipated construction of nuclear plant in percentages of total capacity added each year.

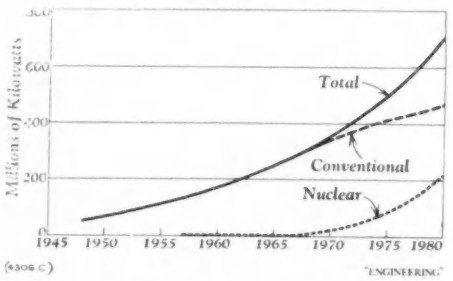


Fig. 3 Nuclear, conventional and total generating capacity estimated up to 1980.

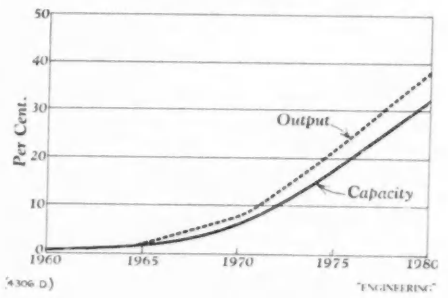


Fig. 4 Estimated nuclear output and installed capacity as percentages of total output.

Capital Costs

Capital costs for first generation nuclear plants are expected to range from 300 dol. to 400 dol. per kilowatt of capacity compared to costs for coal-fired plants which vary from about 115 dol. to 180 dol. per kilowatt, depending on location. Factors keeping nuclear plant costs high in this first generation include high costs for obtaining safety at a time when little factual information is available and the use of expensive materials because of lack of experience with cheaper substitutes. High fuel cycle costs may be expected for the first generation plants because of high fabricating costs and relatively short-lived fuel elements. A recognition of the importance of lowering fuel cycle costs is implicit in the terms of the third invitation under the Power Demonstration Reactor Program, which provide that assistance may be offered for research and development on fuel cycle problems as well as on the reactor plant itself. Costs achieved from first generation nuclear plants may be low enough to be attractive in some countries abroad. The experience gained in supplying the foreign market will be a great help to American manufacturers in achieving further domestic cost reductions.

Second Generation Plants

A second generation of nuclear plants mas be considered as those which go into service between 1965 and 1967. Capital costs for these plants may be expected to approach a competitive level with increases in plant size, more knowledgable approaches to safety needs, and less costly materials. Fuel fabrication and fuel

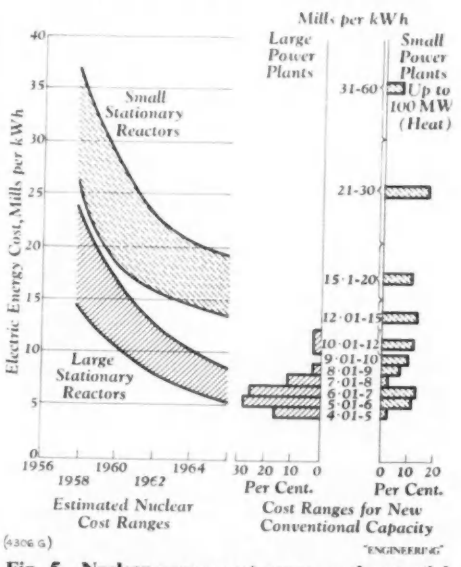


Fig. 5 Nuclear power cost ranges and potential markets for large and small plants, as anticipated in a report by the Chase Manhattan Bank.

life problems may still require further solutions. Nevertheless, plants going into service toward the end of this period, after their initial shake-down, should achieve costs in the range of from 9 to 11 mills. Considering the further cost reductions to be expected during the lifetime of the plants, they should be competitive with modern conventional plants in at least some parts of the United States. Following the second generation, as Fig. 1 indicates, further cost reductions should take place, reaching a range of 6 to 7 mills by 1980. This would make nuclear power competitive with conventionally fuelled plants in all except a few parts of the United States.

By the end of 1959, ten experimental plants should be producing nuclear power. Only one of these, however, the Shippingport pressurised water reactor (PWR) is a large-scale plant, and total nuclear generating capacity at the end of 1959 should be of the order of only 130 MW. These first nuclear plants with their expected outputs are listed in Table I. In addition some response is expected to the Commission's third invitation under the Power Demonstration Reactor Programme which specifies that proposals must be for plants able to produce power by June 30, 1962. Some additional plants may be built entirely with non-A.E.C. financing, some entirely with A.E.C. financing. The first generation plants announced

TABLE I *Nuclear Power Plants Expected to be in Operation by the End of* 1959

Name	Location	Electrical MW
Federal Government-owned		
Pressurised Water Reactor (PWR)[2]	Shippingport, Pa.	100·0[1]
Boiling Water Reactor Experiment (EBWR)	Argonne National Laboratories	5·0
Boiling Reactor Experiment No. 4 (BORAX-4)	NRTS, Idaho	2·0
Sodium Reactor Experiment (SRE)[2]	Santa Susana, Calif.	6·0
Homogeneous Reactor Experiment No. 2 (HRE-2)	Oak Ridge National Laboratories	0·3
Experimental Breeder Reactor No. 1 (EBR-1)	NRTS, Idaho	0·2
Experimental Breeder Reactor No. 2 (EBR-2)	NRTS, Idaho	15·0
Army Package Power Reactor No. 1 (APPR-1)	Fort Belvoir, Va.	2·0
Argonne Low Power Reactor (ALPR)	NRTS, Idaho	0·2
Privately owned		
General Electric Co. and Pacific Gas & Electric Co.	Livermore, Calif.	3·0
Total electrical MW		133·7

[1] Represents approximate expected capacity of second core. First core is expected to produce 60 MW (electrical).
[2] Electric generating portion of plant privately owned.

TABLE II. *Nuclear Power Plants Planned to Come into Service During First Generation* (1960-64)

Operating Organisation	Location	Electrical MW
Power Reactor Development Company, Incorporated	Monroe, Michigan	100·0
Yankee Atomic Electric Co.	Rowe, Massachusetts	134·0
Consumer Public Power District	Beatrice, Nebraska	75·0
Rural Cooperative Power Association	Elk River, Minnesota	22·0[1]
Wolverine Electric Cooperative	Hersey, Michigan	10·0[1]
Chugach Electric Association, Incorporated	Anchorage, Alaska	10·0
City of Piqua, Ohio	Piqua, Ohio	12·5
Commonwealth Edison Co.	Dresden, Illinois	180·0
Consolidated Edison Co. of New York	Indian Point, New York	236·0[2]
Pennsylvania Power and Light Co.	[3]	150·0
Florida Nuclear Power Group	[3]	200·0
Carolinas-Virginia Nuclear Power Associates, Incorporated	[3]	10·0-30·0
Middle South Utilities, Incorporated	[3]	20·0
New England Electric System	[3]	200·0
Northern States Power Co.	[3]	60·0
Ohio Valley Group	[3]	200·0
Pacific Gas and Electric Co.	[3]	[3]
Northwest Power Group	Near Hanford, Washington	[3]

[1] Approximately 80 per cent. nuclear.
[2] 140 MW nuclear; 96 MW oil-fired superheat.
[3] Not yet announced.

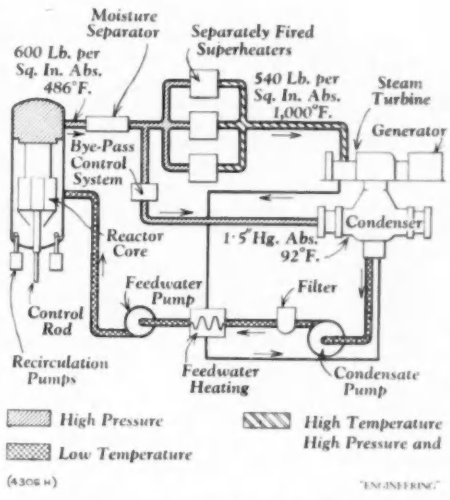


Fig. 6 Schematic layout of controlled recirculation boiling-water reactor to be built by Allis-Chalmers for Northern States Power Company.

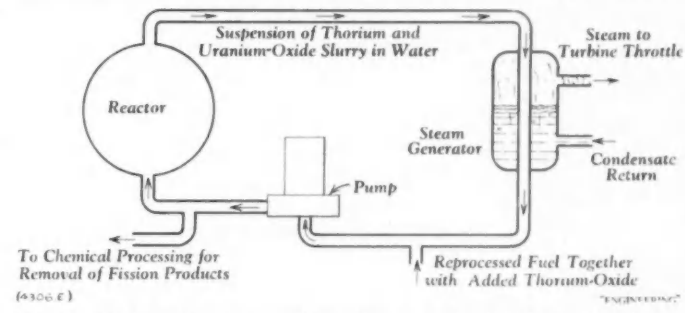


Fig. 7 Single-region aqueous slurry homogeneous breeder reactor being studied as part of the Pennsylvania Advanced Reactor Project (PAR).

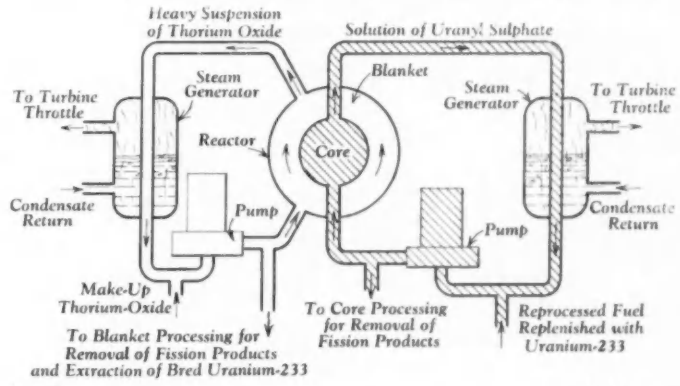


Fig. 8 Two-region aqueous breeder reactor, the last of four homogeneous reactor designs which have been examined prior to the construction of a power reactor based on this system.

by the end of last February are listed in Table II. With due allowance for additional plants it is estimated that the total installed nuclear capacity at that time will be about 2·5 million kW (2,500 MW). (For reactor systems chosen for projected stations see Atomic Review last December 14.)

Turning Point

Toward the end of this first generation it is felt that a turning point may occur when a fairly large number of power producers and equipment manufacturers will become confident that plants can be planned and designed which will be economic when built and successfully operated over a long period of time during which coal and oil prices would be increasing slowly. If allowance is made for time lag the curve of nuclear installations as percentages of total appear as represented in Fig. 2. It will be seen that an expansion phase is expected beginning in 1967 when added nuclear capacity is estimated as 8 per cent. of total additions. Thereafter, this percentage should begin to increase sharply until in 1980 two-thirds of all capacity added will be nuclear. Thereafter the rate of increase may be expected to decline as a near-saturation point is reached. The non-nuclear portion may be expected ultimately to hold steady at about 25 per cent. of capacity added each year, in the form of hydro-electric plants, very small plants or plants located where fossil fuel costs are very low.

TABLE III *Estimated Nuclear and Total Utility Generating Capacity* (1955-80, *in millions of electrical kilowatts*)

Year	Total Capacity	Nuclear Capacity	Nuclear as Percentage of Total
1955	116·3	—	—
1960	175·3	0·8	0·5
1965	251·7	4·0	1·6
1970	360·3	22·6	6·3
1975	500·0	88·9	17·8
1980	700·0	227·2	32·5

These results are shown in Fig. 3.

On the assumptions already outlined the authors estimated future United States capacity as indicated in Table III. The results are shown graphically in Fig. 3. Forecasts of energy output from nuclear plants involve slightly higher percentages of totals than do the capacity estimates given. The revised results are plotted in Fig. 4. The reason for the difference is that nuclear plants may be expected to operate at higher average load factors than the average of conventional plants. The estimates for output at specified years are listed in Table IV.

Second Opinion

The importance of anticipating the likely trend of nuclear development is underlined by a booklet recently published by the Chase Manhattan Bank of New York. Prepared by Dr. Paul F. Genachte, director of the Bank's Atomic Energy Division, the report is entitled "Moving Ahead with the Atom," and deals concisely with important aspects of nuclear energy, from reactor systems, power production and propulsion to mining, processing and the use of radio-active isotopes. Copies may be obtained from the Chase Manhattan Bank, Direct Mail Department, 44 Pine-street, New York 15, N.Y., U.S.A.

In particular, Dr. Genachte examines the probable cost of nuclear power. He states that estimates are still largely theoretical and will continue to be so until actual operating experience is gained. Capital investment in a nuclear power plant is known to range from 220 dol. to 350 dol. per kW, depending on the type and size. This may vary from 20 to 200 MW, and capital costs covering interest, depreciation and taxes may vary from 4 to 7 mills per kWh at 80 per cent. load factor. The nuclear fuel cost of reactors is estimated to be about 2·5 to 4 mills per kWh. In addition, probable operating and maintenance costs of 1·5 mills per kWh bring the total cost of nuclear energy to about 8 to 12 mills per kWh and even this will only be achieved after a second round of large power

TABLE IV *Estimated Nuclear Output Related to Total Utility Output* (1955-80, *in* 10^9 *kilowatt hours*)

Year	Total Utility Output	Nuclear		Average Load Factor (per cent.)
		Output	Per Cent. of Total	
1955	546·3	—	—	—
1960	811·9	2·4	0·3	60
1965	1,175·8	22·8	1·9	80
1970	1,700·1	133·9	7·8	80
1975	2,400·0	526·3	21·9	75
1980	3,400·0	1,285·9	37·8	70

reactors is built. This is in excess of conventional power costs in the United States to-day, which average 7 to 8 mills per kWh. The booklet includes several graphs analysing anticipated development, including that reproduced in Fig. 5, which shows estimated nuclear power cost ranges and potential markets for large and small reactors.

Third Opinion

Recently Mr. Willard F. Libby of the U.S.A.E.C. stated that the output of electrical power from nuclear reactors in the United States would probably amount to between 50,000 and 75,000 MW by 1975, a capacity requiring several hundred reactors. Installed capacity would exceed 1,000 MW by 1962 and be between 3,000 and 4,000 MW by 1965. The rate of installation would be from 8,000 to 12,000 MW a year by 1975. He reported that an A.E.C. survey had given the total number of reactors built or proposed in the United States as 231, of which 94 were in the planning stage, 46 were under construction, 74 completed and a further 17 completed but now dismantled.

Northern States BWR Plant

The nuclear power plant planned by the Northern States Power Company and referred to in Table II, is expected to cost between 20 and 25 million dol., and although a site has not yet been chosen it is expected to be at or near Sioux Falls, South Dakota. It will thus be near the junction of that state with Minnesota and Iowa, which with North Dakota and Missouri comprise the area covered by the power company.

The plant chosen by the Northern States group is reported to be an advanced type of boiling-water reactor giving an electrical output of 60 MW, and the main contractor is to be the Allis-Chalmers Manufacturing Company of Milwaukee, Wisconsin, who have been concerned in the construction of EBWR (Atomic Review, February 1 and January 18). The design is illustrated schematically in Fig. 6 and is related to the system discussed in Atomic Review on November 23, 1956. Described as a controlled-circulation boiling reactor, it is said to give high energy output per unit volume (133 MW heat), which is achieved by continuously circulating a large quantity of water through the 5 ft. high 5 ft. diameter cylindrical core. Presumably this forced circulation will also serve to reduce the inherent instability associated with boiling reactors, since the total water passing through the reactor core will contain relatively few steam voids per unit volume, steam being drawn off promptly on formation. Reactor power will be controlled by variation of the pumping rate but there will also be an orthodox control-rod system. Steam will separate centrifugally and superheated by conventional-fuel burners. The reactor core is contained in a 9 ft. diameter 23 ft. high vessel, which will contain water at 600 lb. per sq. in. and 486 deg. F. (252 deg. C.). The bank of superheaters will then raise the temperature to 1,000 deg. F. (538 deg. C.) and steam will be delivered to the turbine throttle at 540 lb. per sq. in. The steam flow will be about 502,000 lb. per hour.

Michigan Fast Breeder

The U.S.A.E.C. is to assist the Power Reactor Development Company of Detroit in the development of the large-scale nuclear power plant now being built at Monroe, Michigan. The plant will be powered by a sodium-cooled fast breeder reactor producing at least 100 MW of electricity. Construction costs, which will total about 47 million dols., will be borne by the company. The A.E.C. will provide up to 4,450,000 dol. in assistance, which will comprise research and development work in A.E.C. facilities, consultant and information services, and training of personnel. This contract is the second under the Power Demonstration Reactor Programme aimed at bringing private resources into the development of reactor technology. The first contract was concluded last June with the Yankee Atomic Electric Company of Boston, Massachusetts. Although hearings on union objections to the Monroe breeder reactor have been resumed, the project is now likely to proceed unhampered.

Homogeneous Reactor Project

Last week in Atomic Review we noted some of the problems which must be solved before homogeneous reactors, using either light or heavy water as moderator, can be profitably built and operated. In the United States a study of such a system is now in progress which is intended to serve as a basis for a power plant. The Pennsylvania Advanced Reactor Project (PAR) is a major development undertaking sponsored by Westinghouse Electric Corporation and the Pennsylvania Power and Light Company. Its function is to carry out the experimental and analytical studies leading to the design of an aqueous homogeneous reactor plant having an electrical output of 150 MW. The plant is to operate on the P.P. and L. system in Eastern Pennsylvania and is planned to be in operation in 1962.

Four possible systems have been examined. The first three are single-region reactors and the fourth has two concentric zones. In the first (simple burner) highly enriched uranium, in the form of uranyl sulphate, is used and no plutonium produced; in the second (heavy solution) there is only slight enrichment so that a very concentrated solution of the sulphate is necessary and some plutonium is produced; the third (single-region slurry) employs the thorium-uranium 233 cycle and is in fact a breeder reactor since more fuel is produced than consumed; and the fourth (two-region slurry) also uses a thorium oxide suspension in the outer (breeding) zone with uranyl sulphate in the inner zone. Breeding in the fourth system is even better than in the third. A comparison of the four systems has been made and the results published in the March, 1957, issue of the "Westinghouse Engineer". Table V is a summary of the conclusions. Figs. 7 and 8 show two of the systems studied.

Those responsible for the study report that thorium-oxide slurries have been pumped in concentrations and at temperatures appropriate to the single-region reactor for more than 5,000 hours. Significant inroads have been made on many of the major development problems. Although much remains to be done, solution of the technical problems associated with the plant within the established time scale appears feasible. With regard to the economics of the plant, more caution is in order. While in the case of a breeder plant the bare fuel cost is essentially nil, the fixed charges are quite another matter. The cost analysis for a first preliminary plant is only now being completed but it is certain to be quite high. On the other hand, if present efforts in the direction of system simplification and the development of maintenance techniques are successful, a competitive power plant is in sight.

TABLE V Comparison of Several Homogeneous Reactor Systems

Type	Fuel	Basic Cycle	Comments
Simple Burner	Highly enriched U 235, as solution of uranyl sulphate	Straight burning of U 235	Relatively low plant cost but high fuel cost, making the total energy cost non-competitive
Heavy Solution Reactor	Slightly enriched U 235 in highly concentrated uranyl sulphate solution	Straight burning of U 235 plus conversion of U 238 to plutonium. Plutonium can be burned in place or sold as by-product	While the fuel cost would be less than that of the simple burner, problems involving corrosion and thermal stability are more severe; hence probably not technically feasible in the immediate future
Single-Region Slurry Reactor	Mixture of oxides of thorium and uranium, in slurry form	Straight burning of U 235. Conversion of thorium 232 to uranium 233; U 233 can be burned in place or sold as by-product	Can produce from thorium at least as much fissile material as it consumes; consequently has excellent possibilities for competitive power
Two-Region Slurry Reactor	Central core of highly enriched uranyl sulphate, surrounded by blanket of thorium-oxide slurry. Two fuels separated by core liner	Straight burning of U 235 in core. Neutrons from core convert thorium to U 233; U 233 also fissions, thus producing more heat	Can produce from thorium even more fissile material than it consumes; consequently could possibly have negative fuel costs. However, the technical problems to be solved appear much more difficult than in the case of the single-region reactor

General Notes

Baghdad Pact Nuclear Centre

On March 30, the Baghdad Pact Nuclear Centre was opened by Sir John Cockcroft. The purpose of the laboratory is to promote the peaceful applications of atomic energy in the countries which have collaborated in its foundation—Iraq, Iran, Pakistan and Turkey. Radiation problems are to be studied and students and graduates will be trained in the possible application of radioactive isotopes to medicine, agriculture and industry. Great Britain is assisting in its establishment and operation during the early years, largely by lending scientific staff from Harwell and by providing equipment. The Atomic Energy Research Establishment at Harwell has also trained the initial staff from the participating countries. The first Director of the Centre will be Mr. W. J. Whitehouse, formerly of Harwell.

Display in Ankara

A photographic display on British nuclear research achievements is in the programme of British Week organised by the British Council and the Turkish-British Society at Ankara from April 9 to 16.

Nuclear Staff for Shipbuilding

It has been reported that the Birkenhead shipyard of Cammell Laird and Company are prepared to employ a small number of graduates with a knowledge of nuclear engineering in their design study departments.

Softly Softly

When the benefits of an enterprise are debatable and its consequences obscure there can be little profit in pursuing it, particularly when no-one is quite certain of its purpose. To detonate a hydrogen bomb in such a way that the explosion remains undetected is no doubt an admirable achievement—except when the object of the exercise is to prove the bomb's existence. There is a suggestion of squeamishness in testing "a little bomb"; a big bomb, capable of casting radioactive evidence over the entire earth, would surely provide a much more convincing demonstration. The risk, we are told, is calculated, so why the hesitation? Can it be that the authorities, dressed in a brief scientific sophistry, are beginning to feel, like Hans Andersen's emperor, just a little bit naked?

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Discussion on "The Thirteenth Edition of the Institution of Electrical Engineers' Regulations for the Electrical Equipment of Buildings." E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, Strand, W.C.2. Tues., April 16, 6.30 p.m.*

British Institute of Management

LONDON
"Appointment of an Employee Director," by E. O. Landau. Thurs., April 25, 6.30 p.m.

British Institution of Radio Engineers

LONDON
"Properties of Semi-Conductor Devices," by Dr. A. A. Shepherd. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., April 24, 6.30 p.m.*
EDINBURGH
Annual General Meeting at 6.30 p.m. "Special Process Instrumentation in Atomic Energy Projects," by H. Bisby, at 7 p.m. Scottish Section. Department of Natural Philosophy, The University, Edinburgh. Fri., April 26.

Building Centre

LONDON
Films on "Waterproofing Building Structures," exhibited by by Tretol Ltd. Wed., April 17, 12.45 p.m.
Film on "Hadrian Paint," exhibited by Smith and Walton Ltd. Wed., April 24, 12.45 p.m.

Chemical Society

ST. ANDREWS
"Some Bimolecular Gas Reactions," by A. F. Trotman-Dickenson. St. Andrews and Dundee Branch. Chemistry Department, St. Salvator's College, St. Andrews. Fri., April 26, 5.15 p.m.

Combustion Engineering Association

LONDON
"Selection of Plant for Power and Process Requirements," by R. Nichol. Waldorf Hotel, Aldwych, W.C.2. Wed., April 24, 10.30 a.m.
LEEDS
"Development of the Houldsworth School of Applied Science," by Professor A. L. Roberts. Lecture Theatre, Houldsworth School, The University, Leeds 2. Mon., April 15, 11 a.m. (Followed by a visit to the School's laboratories in the afternoon.)

Engineers' Guild

EDINBURGH
Annual General Meeting. Edinburgh Centre. Scottish Liberal Club, 109 Princes-street, Edinburgh. Mon., April 29, 6.15 p.m.

Illuminating Engineering Society

BATH
Annual General Meeting and Film Evening. Bath and Bristol Centre. Offices of the South Western Electricity Board, Bath. Fri., April 26, 7 p.m.
BIRMINGHAM
"A Feminine Point of View on Domestic Lighting," by Mrs. Kay Hudson. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., April 26, 6 p.m.
CHELTENHAM
Annual General Meeting. Gloucester and Cheltenham Centre. Bell Vue Hotel, Cheltenham. Tues., April 16, 6.30 p.m.
LEICESTER
Annual General Meeting. Leicester Centre. Royal Hotel, Leicester. Mon., April 15, 6 p.m.

Incorporated Plant Engineers

BLACKBURN
Brains Trust Meeting. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., April 18, 7.30 p.m.
CARDIFF
Discussion on "Gas in Industry." South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., April 16, 7.15 p.m.
CHESTER
"Industrial Hydraulics," by D. V. Rowles. Merseyside and North Wales Branch. Stafford Hotel, City-road, Chester. Thurs., April 18, 7.15 p.m.
ROCHESTER
"The Plant Engineer and Work Study," by H. A. Gomm. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., April 17, 7 p.m.
SHEFFIELD
"Welding Applied to Maintenance," by A. O'Donnell. Grand Hotel, Sheffield. Thurs., April 25, 7.30 p.m.

Institute of Metals

LONDON
May Lecture on "Education in Science and Technology," by Sir Eric Ashby. Royal Institution, Albemarle-street, W.1. Mon., April 29, 6.30 p.m.
SHEFFIELD
Film Evening. Sheffield Local Section. Engineering Lecture Theatre, The University, St. George's-square, Sheffield. Mon., April 15, 7.30 p.m.

Institute of Physics

ABERYSTWYTH
"Instrumentation of the Liverpool Synchrocyclotron," by Dr. B. Collings. South Wales Branch. University College of Wales, Aberystwyth. Fri., April 26, 5.30 p.m.
BIRMINGHAM
"The Strength of Metals," by Dr. A. H. Cottrell. Midland Branch. Regent House, Birmingham. Thurs., April 25, 7 p.m.

Institute of Road Transport Engineers

DURHAM
Annual General Meeting. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., April 16, 7 p.m.
GLASGOW
Annual General Meeting. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., April 15, 7.30 p.m.
LEEDS
Annual General Meeting. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds 1. Thurs., April 18, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"Manufacture of Cortisone," by Ben Edgington and D. A. Johnson. Geological Society, Burlington House, Piccadilly, W.1. Tues., April 16, 5.30 p.m.*
MANCHESTER
"Forty Years on—If the Oil Wells Run Dry," by Professor E. S. Sellers. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues., April 16, 6.30 p.m.

Institution of Civil Engineers

LONDON
"Railway Diesel Traction and Associated Problems," by A. B. Henderson. Tues., April 16, 5.30 p.m.*
LEICESTER
"Construction of Cofferdams," by S. Packshaw. East Midlands Association. County Rooms, Hotel-street, Leicester. Tues., April 16, 6.15 p.m.
NOTTINGHAM
Annual General Meeting. "Some Uses and Advantages of Computing Machines in the Solution of Engineering Problems," by A. C. Stewart. East Midlands Association. Mechanics' Institute, Trinity-square, Nottingham. Mon., April 29, 6.15 p.m.
SHEFFIELD
Annual General Meeting. "Skidding Resistance of Roads and the Requirements of Modern Traffic," by C. G. Giles. Yorkshire Association. Grand Hotel, Sheffield. Fri., April 26, 6.15 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "The Future of Plastics in Power Cables," opened by C. C. Barnes. Mon., April 15, 5.30 p.m.*
Discussion on "The Measurement of Currents in High-Voltage Circuits Without Orthodox Current Transformers," opened by M. Kaufmann and Dr. A. J. King. Measurement and Control Section. Tues., April 16, 5.30 p.m.*
"The 138 kV Submarine Power Cable Interconnecting the Mainland of British Columbia to Vancouver Island," by Dr. T. Ingledow, R. M. Fairfield and others. Thurs., April 25, 5.30 p.m.*
Informal Evening. Talks on "Radio in Air-Sea Rescue," introduced by G. W. Hosie, D. Kerr and W. Kiryluk. Radio and Telecommunication Section. Mon., April 29, 5.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Annual General Meeting. "The Analysis of Plain Bearing Failures," by P. P. Love. Tues., April 16, 6.30 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
Annual General Meeting. "Air Conditioning in the British Isles," by J. C. Knight. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Tues., April 30, 7 p.m.

Institution of Locomotive Engineers

LONDON
"Painting and Cleaning of Rolling Stock," by F. Fancutt. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., April 24, 5.30 p.m.*
DARLINGTON
"Unification of Freight Vehicles on Overseas Railways," by A. Campbell. Newcastle Centre. Imperial Hotel, Grange-road, Darlington. Mon., April 15, 6 p.m.
DERBY
"Diesel Locomotive Building and Maintenance," by T. F. B. Simpson. Midlands Centre. Midland Hotel, Derby. Tues., April 16, 7 p.m.
NEWCASTLE-UPON-TYNE
"Painting and Cleaning of Rolling Stock," by F. Fancutt. Newcastle Centre. Gas Board's Showrooms, Grainger-street, Newcastle-upon-Tyne. Mon., April 15, 6 p.m.

Institution of Mechanical Engineers

LONDON
"Pneumatic Controllers for Process Control," by K. S. Jones. London Graduate Section. Tues., April 16, 6.30 p.m.*
Discussion on "The Importance of Internal Communications in an Engineering Works." Industrial Administration and Engineering Production Group. Wed., April 17, 6.45 p.m.*.
Discussion on "Removal of External Deposits on Boilers." Steam Group. Thurs., April 25, 6.45 p.m.*
BIRMINGHAM
"Some Interesting Industrial Furnace Applications," by F. Dickinson. Midland Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., April 18, 6.30 p.m.

Institution of Production Engineers

LONDON
"Corporate Responsibilities of Production Engineers," by Austen Albu. South Eastern Region. Royal Empire Society, Craven-street, Strand, W.C.2. Thurs., April 18, 7 p.m.
PETERBOROUGH
"Production of Raw Materials from Rolling Mills," by J. McLauchlan. Peterborough Section. White Lion Hotel, Church-street, Peterborough. Wed., April 17, 7.30 p.m.
WOLVERHAMPTON
"Modern Trends in the Application of Pneumatics," by R. Cooper. Joint meeting of Wolverhampton and Wolverhampton Graduate Sections. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., April 17, 7.15 p.m.

Institution of Railway Signal Engineers

BRISTOL
"Axle Counters," by H. A. Cod. Bristol Branch. Meeting Room above Main Booking Hall, Temple Meads Station, Bristol. Fri., April 26, 5.30 p.m.*

Institution of the Rubber Industry

MANCHESTER
Annual General Meeting. Manchester Section. Engineers' Club, Albert-square, Manchester. Mon., April 15, 6.45 p.m.

Institution of Structural Engineers

LEEDS
Annual General Meeting. "Civil Engineering Construction under Water," by J. R. Malcolm. Yorkshire Branch. Offices of the Yorkshire Electricity Division, 1 Whitehall-road, Leeds. Wed., April 17, 6.30 p.m.

Institution of Water Engineers

LONDON
Annual General Meeting. "River Board Functions," by C. H. H. Mercer. South Eastern Section. Institution of Civil Engineers, Great George-street, S.W.1. Mon., April 15, 2.30 p.m.

Junior Institution of Engineers

MANCHESTER
Repetition of Presidential Address on "Fuel Economy and Heat-Electric Generation," by Bryan Donkin. North Western Section. Engineers' Club, Albert-square, Manchester. Tues., April 30, 7.30 p.m.
SHEFFIELD
Repetition of Presidential Address on "Fuel Economy and Heat-Electric Generation," by Bryan Donkin. Sheffield Section. Royal Victoria Hotel, Sheffield. Mon., April 29, 7.30 p.m.

Liverpool Engineering Society

LIVERPOOL
Annual General Meeting. Wed., April 17, 6 p.m.

North East Coast Institution of Engineers and Shipbuilders

MIDDLESBROUGH
"Failure of Welded Steel Structures," by T. W. Bushell. Tees-Side Branch. Cleveland Scientific and Technical Institution, Corporation-road, Middlesbrough. Mon., April 15, 6 p.m.

Royal Aeronautical Society

LONDON
"Simulation Techniques in Aeronautics," by J. J. Foody and R. A. Paul. Tues., April 16, 7 p.m.

Royal Meteorological Society

LONDON
Annual General Meeting. Presidential Address on "An Outlook on Meteorology and the Society," by Dr. R. C. Sutcliffe. Wed., April 17, 5 p.m.*

Royal Microscopical Society

LONDON
"Modern Metallography and Some of Its Results," by Dr. D. McLean. Wed., April 17, 5.30 p.m.

Royal Society of Arts

LONDON
"The British Council and the Commonwealth," by Richard Seymour. Tues., April 16, 5.15 p.m.*

Royal Statistical Society

LONDON
Discussion on "The Use of Electronic Data Processing Equipment," opened by J. H. H. Merriman, D. T. Caminer, H. L. Barman and Dr. H. Durant. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., April 17, 5.15 p.m.*

South Wales Institute of Engineers

CARDIFF
"Underground Filling of Hydrox and Cardox," by Stanley Atherton. Thurs., April 18, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's London, S.W.1. (WHItehall 5536.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1. (ABBey 6740.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Microscopical Society, Tavistock House South, Tavistock-square, London, W.C.1. (EUSton 2048.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

REINFORCED-CONCRETE STRUCTURES WITH A VERY SMOOTH SURFACE

L.C.C.'s New Sewage Sedimentation Plant

An extensive contract, involving the use of several travelling shutters in the construction of extensive reinforced concrete aeration channels for which a "very smooth" surface was specified, is nearing completion at the London County Council's Northern Outfall Works, where the sewage from the northern suburbs of London is treated before being passed into the lower reaches of the Thames. At present the works handle up to 200 million gallons of raw sewage each day. The whole of the flow is given a primary sedimentation treatment and roughly one-third receives further secondary treatment before being discharged into the river. Completion of the new channels will give activated sludge treatment to a further 60 million gallons each day.

On receipt of the sewage, all of it now passes through detritus pits where sand and gravel are removed to be dumped at the site or used as fill. The flow then passes through screens to remove coarse suspended matter before it goes to the primary sedimentation tanks where the finer suspended matter is allowed to settle. The sludge from the tanks is pumped to storage tanks, later to be taken out to sea in dumping vessels. The completion of the new diffused-air plant, which is being built by Richard Costain, Limited, will allow secondary treatment to be given to a total of two-thirds of the dry-weather flow, the remaining one-third being discharged to the river with primary treatment only. Commissioning of the plant will mean that the discharge will contain less than 80 parts of solids in 1 million and some dissolved oxygen; the plant will thus make a significant contribution to the improvement of the river.

The works comprise the construction of the main supply channel leading from the primary sedimentation tanks; the operating gallery, from where the process is controlled; the aeration channels; the final settling tanks; and outfall channels leading to the existing main effluent channel. The whole of the new works consists of, in effect, several hundred feet of large cross-section channels of reinforced concrete. Built as it is above soft alluvial deposits overlying chalk, the structure has been constructed on 10,500 piles, cast on site, 14 in. and 12 in. square and varying between 17 ft. and 51 ft. in length.

A pertinent point of the specification was that the concrete facing of the channels, where exposed or in contact with liquor, should have a "very smooth surface when the shuttering is struck." It was specified that such a finish should be obtained by the contractor taking particular care and by the use of special linings to the shutters and of appropriate punning methods; a separate item was included in the schedules to cover the cost of obtaining this finish. The effect of the phrasing is to expressly forbid rubbing down or dressing of the surface, for such finishes are very liable to powder with time, leaving a rough surface and freeing fine dust which would be detrimental to the mechanical equipment. The specification requires the finish to be very smooth to the "satisfaction of the engineer," but no precise definition of smoothness is included. This superior finish is wanted because it will reduce the collection of sludge that is liable to occur on the walls if the surface is rough and such "collections" tend to grow, producing bacteria for which no provision is made.

To meet the specification of such smooth-faced concrete walls the contractors have lined the formwork with steel plate shuttering and have made use of a water/cement ratio as high as 0·5. The greater part of the concrete has been pumped from central batching units to the point of placing. Wall sections can be gauged from the illustrations, a typical height being about 15 ft. To eliminate free fall of the concrete—which is liable to cause segregation—the concrete received for placing is delivered into a small combination hopper and chute which cuts down the maximum fall to about 5 ft. Consolidation has been obtained primarily by the use of long poker vibrators, gates in the lower sections of the shutters allowing access to the bottom lifts. Some external vibrators were also fixed to the formwork. Cold-weather concreting was made possible by extra external wooden cover over the shutters, so retaining an air blanket and thereby minimising the effect of frost, though the mild winter must have contributed greatly in this respect.

After some initial trials a combination of concrete consistancy, placing technique and consolidation was worked out that has enabled a very satisfactory finish to be obtained on the walls. Very little rubbing down has proved to be necessary and, of course, the use of large steel sheet formwork has meant that there have been very little of the bleeds met with timber shuttering.

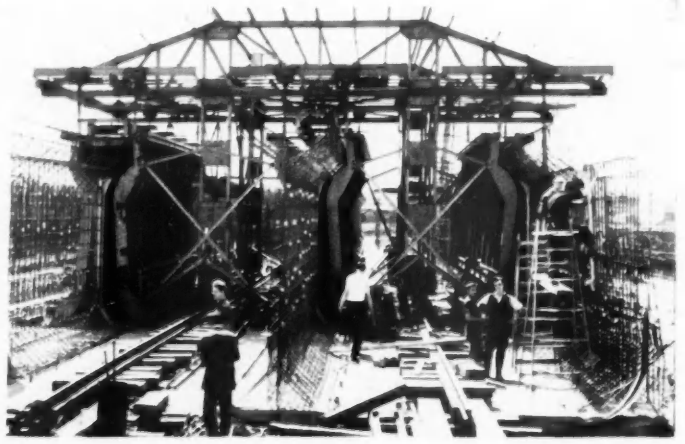
The extent of the work is worthy of note, and a few leading dimensions give some idea of the size of the contract. The main supply channel is 600 ft. long, 18 ft. wide by 15 ft. deep. The operating gallery—the "nerve centre"—is about 1,000 ft. long, 50 ft. wide and 25 ft. deep; it houses much of the culverts, pipework, airlines all of which are in passages for easy maintenance, and generally speaking the complexity and variation of shape was such that a travelling shutter could not be used, so that conventional timber formwork had to be built *in situ*. The aeration channels, in which compressed air is passed through the sewage (1·5 cub. ft. per gallon), is divided into six sets, each 390 ft. long by 140 ft. wide and 15 ft. deep. Each set is sub-divided by "wine-glass" walls into eight channels with openings at alternate ends so that a flow path of about 3,000 ft. has been provided within each set. After the aeration channels, the treated sewage goes to one of 15 final settling tanks, each of 110 ft. in diameter by 15 ft. deep, and thence to the outlet channel, 1,200 ft. long by 20 ft. wide and some 10 ft. deep.

The total volume of reinforced concrete on the site was of the order of 70,000 cub. yd. and the greater part of the mixing was done in one of two batching plants, one delivering through a 6 in. pump, the other through a 4 in. Where the point of placing has been beyond the range of the pumps, dumpers have been used to transport the concrete.

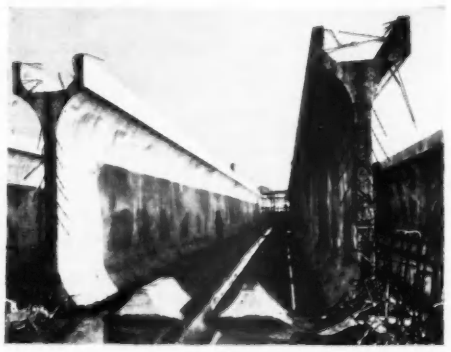
Three different types of cement have been used on the contract. All piles and all work below the level of approximately 8 ft. below ground level were constructed in sulphate-resisting cement. In the case of the pile casting plant this cement was delivered in pressure bulk. In all other instances, due to the fact that concrete volumes have been relatively small, the sulphate-resisting cement has been delivered in bags and fed by hand into the concrete mixers. Portland cement is used on the main construction and is delivered in bulk by tipper lorries. On certain sections of the work rapid-hardening Ferrocrete cement in bulk is used, mainly in wall and roof construction where progress depends on early shutter striking.

In the aeration channels, settling tanks, main supply channel and the effluent channels, the degree of repetition has been such that the contractors have been able to use purpose-made travelling shutters. The largest of these shutters is that used in the aeration channels and it is shown in one of the illustrations. It has been designed to allow three walls, each 32 ft. long and 15 ft. high, at 17 ft. 6 in. centres, to be concreted in one operation. The six shutters required for this work have an area of 375 sq. yd. and are hung from a steel gantry which travels on four sets of twin bogies, propelled by fixing anchors and hauling through hand winches. The shutters are locked into place by cross-members, by fixing to holding-down bolts previously left in the channel floor, and by through-bolts in ferrules left in the walls themselves. When concreting is finished on each section, the shutters are raised on the gantry and moved forward to the next-but-one section. In general, a 48 hour cycle has been operated, one day to strike, move and refix the shutters and one day to pour the concrete, 66 cub. yd. to a section. Free time before placing the missed intervening section has been upwards of four weeks and copper sealing strips have been incorporated at the joints.

The work described above began in 1955 and is due for completion early in 1958. Main concreting is planned to finish in the autumn of this year, leaving six months or so for the installation of valves, penstocks and pipework (by sub-contractors) and the erection of coping stones, handrails, etc. Another section of the contract provides for a new power-house where eight Ruston and Hornsby gas-turbines are to be installed; roughly three-quarters of the fuel they are to use will be obtained from the methane collected from the treatment plant on the site.



The specification for the new tanks at the L.C.C.'s Northern Outfall sewage works required that the concrete surface, where exposed or in contact with the affluent, should be very smooth. Lined shutters and careful consolidation produced the necessary finish. Long runs of concrete walls with little variation are ideal for travelling shutters. The gantry shown above carries the formwork for three walls, of the type illustrated below.



In Parliament

£3,350 MILLION WORTH OF ENGINEERING

As readers of these columns will be aware, a number of important debates have lately taken place in the House of Lords on industrial and economic problems. Last week's debate, on the problems which are likely to arise in the course of the future development of the fuel and power industries in Britain, was of special interest, if only because it was the occasion of an extended statement by Lord Mills, the Minister of Power, on the plans of the Government in respect of forthcoming projects for the utilisation of nuclear power.

After outlining the probable future trends of power requirements in Western Europe generally, and in Britain in particular, Lord Mills said that the cost of this country's programme for providing some 6,000 MW by means of atomic energy projects, by 1965, would be £919 million. That figure represented the cost of the stations themselves, which would be £742 million, and the value of the initial uranium fuel charge, £177 million. The estimate for the conventional power stations coming into use concurrently with these nuclear stations, between 1961 and 1965, was £316 million, while that for the associated transmission lines was £225 million. The addition of these three amounts gave a total of £1,460 million as the cost of all the new stations and their associated transmission lines coming into commission between 1961 and 1965.

A programme for the erection of conventional stations and their transmission lines was already under way, to meet the growth in the demand for electricity. Some £630 million would be spent on these projects between now and the early 1960s. Then there would be an expenditure of some £220 million, to be met before the end of 1965, in respect of conventional and nuclear stations which will not come into operation until after that date. The total expenditure on generation and bulk transmission, from the present time until 1965, would amount, therefore, to about £2,310 million. In addition to this expenditure, it would be necessary to provide about £1,000 million over the same period for local distribution and around £40 million for extra working capital, giving a grand total of some £3,350 million.

The additional investment required by the inclusion of nuclear power plants in the programme, compared with what would have been needed if the programme involved only conventional stations, amounted, in round figures, to an extra £750 million, nearly £200 million of which would be in respect of the initial fuel charges.

CHEAPNESS OF URANIUM

Earlier, Lord Mills said that fuel consumption in Britain had increased by 2½ per cent. per annum since the war, in spite of all the efforts, and they had been considerable, which had been made to promote fuel efficiency. The fuel and power industries must not be allowed to be a brake on invention and production.

If Britain's standard of living was to be doubled during the next 25 years, as the Government desired, there would have to be an annual increase of 3 per cent. in the national income and it had been calculated from detailed estimates for each section of the national economy that that would involve an increased fuel demand equivalent to about five million tons of coal a year. In addition, the country must strive to abolish coal imports and to restore the cuts in coal exports which had been imposed a year and a half ago.

To rely upon oil to fill the whole of the gap in fuel needs would be a serious burden on the balance of payments. The coal investment programmes could not promise, so far as could be foreseen at present, to produce more than an additional 19 million tons, by 1965, towards the additional 60 million tons a year required. The nuclear power programme, if the higher level of 6,000 MW was achieved, would provide the annual equivalent of 18 million tons of coal at the end of 1965. Oil imports would have to meet the balance, and that would probably require an increase of about 50 per cent. above last year's net imports of 30 million tons of oil.

The cost of importing fuel for nuclear power would be considerably less than the cost of importing conventional fuels. It was true that, in the early years, the provision of initial fuel charges would be costly, but the annual replacements would cost very much less and, broadly speaking, over the life of the nuclear power stations, estimated at 20 years, uranium imports would cost from one-tenth to one-fifth of what would be the price of coal or oil, if those materials had had to be imported instead.

Present sources of uranium included South Africa and Australia, and it was expected that considerable supplies would shortly be available from Canada. The United States had had an option on certain uranium supplies in Canada, which they had now relinquished in favour of this country. He was informed, Lord Mills said, that nuclear power stations were inherently safe and that the system of monitoring them was such that the escape of radioactive material was extremely unlikely.

PINCHING THE ENGINEERS

The debate was opened by Viscount Hall (Labour), who paid a warm tribute to the work which had been carried out at Harwell, commencing from very small beginnings. He said that uranium was the necessary starting point of any plans for using atomic energy. While, for many purposes, atomic energy had many advantages over coal, its great disadvantage was that Britain had no native deposits of uranium. Like oil, uranium had to be imported and the cost was considerable. It had been reported that a single nuclear power station, such as that built at Hunterston, would require a recurring charge of 500 tons of uranium every three years. Britain might well have to buy about 10,000 tons over the next five years at a cost of £20,000 a ton. Fortunately, Britain could produce sufficient graphite, but heavy water had to be imported from the United States at a cost of something like 28 dols. a pound.

Viscount Stonehaven (Conservative) pointed out that what worried him most was whether Britain had the capacity, from the civil engineering point of view, to construct the nuclear power stations required as well as to maintain her engineering exports. Apart from the £140 million programme of the National Coal Board, the £300 million railway projects and the £50 million-worth of work required by the Central Electricity Authority, there was the Forth Bridge, the Whiteinch Tunnel, and the Dartford Tunnel, as well as the need for more steelworks, docks, harbours and oil refineries.

It was all very well for Sir John Cockcroft to say that an ordinary engineer could be taken and trained to make a nuclear engineer in a few months. But from whom was the engineer to be "pinched"? It was no use robbing Peter to pay Paul. There might very well not be enough engineers to go round. It might be there was merit in the idea of inviting Euratom countries to send their technicians, foremen and engineers here to train with our people in our programme.

Lord Lucas of Chilworth (Labour) doubted whether the nuclear power stations were being constructed in the right places. He considered them to be no more dangerous than gasworks or coal mines, and, if sited in built-up areas, the hot water which was pumped out at the rate of 25 million gallons an hour from each station could be used for the district heating of quite a large town, instead of being wasted in heating up the sea by 15 degrees.

Lord Waleran (Conservative) said he was a director of the Ekco Electronics Company, Limited and that he differed from Lord Stonehaven, because he, for one, would not like to see the other countries, who were five, eight or ten years behind Britain in technical knowledge, being taught how to make these stations. Britain's engineers had won a brilliant victory and he begged the Government to see to it that neither politics nor their own decisions prevented this country from reaping the rewards of these men's labours.

Finding Fish from the Air

In the House of Commons, Mr. Hector Hughes (Labour) asked the Minister of Agriculture, Fisheries and Food about the use of aircraft for the location of fish shoals. He said that such a system, if combined with a means of communication between aircraft and ships, could save fuel, time, labour and the depreciation of the fishing vessels. Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry, said that it was too early to predict what economic advantages there might be in the use of aircraft for such a purpose.

Saving Technical Manpower

Mr. Aubrey Jones, the Minister of Supply, told Mr. Austen Albu (Labour) that no estimate could be made at this stage of the saving in the use of scientific and technical manpower which would accrue as a result of the agreement with the United States for the supply of guided missiles.

Bill on Weights and Measures

According to an answer given by Mr. F. J. Erroll, Parliamentary Secretary to the Board of Trade, to Mr. J. Rankin (Labour/Co-operative), the President of the Board hopes to introduce a Bill to amend the law relating to weights and measures, as soon as the parliamentary timetable permits. It will be based upon the recommendations of the Committee on Weights and Measures Legislation.

River Thames Pollution

The sewage treatment improvement programme which was approved on the advice of the Pippard Committee is making good progress. The further stages for which tenders are being invited this year, Mr. Henry Brooke, the Minister of Housing and Local Government, told Mr. N. N. Dodds (Labour/Co-operative), included nearly £10 million worth of new treatment plant for the London County Council; £700,000 worth for the Middlesex County Council; and £600,000 worth for the West Kent Main Sewerage Board. Final reports of the Water Pollution Research Laboratory and the Pippard Committee are likely to be completed later this year.

Use of Decca Navigator

An inquiry was made by Mr. Hector Hughes as to what further extensions were contemplated in the use of the Decca Navigator system. In reply, Mr. Airey Neave, the Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, said that a chain of these stations in Sweden and four chains in Canada were due to come into operation this year. Terms had also been agreed to for the provision of equipment for two other chains in India, to be situated at Bombay and Calcutta, respectively. He understood that the Governments of a number of other countries were considering the adoption of this system.

P.1. Fighter Aircraft

Mr. George Brown (Labour) asked Mr. Aubrey Jones if he would arrange for a proportion of the development batch of the English Electric Company's P.1. fighter aircraft to be made available to the Royal Air Force for simultaneous squadron defence. The Minister said that it was the Government's intention that a proportion of these aircraft should be delivered to the R.A.F.

The cost of modern fighter aircraft varied from about £90,000 to about £250,000, depending upon its type and upon the numbers of that type produced. In 1945, the cost of a typical piston-engined day fighter in mass production was £10,000, approximately.

THE HUMAN ELEMENT

Can Pay be Linked to Productivity?

A suggestion was made in the correspondence column of *The Times* for linking wage rates to something other than the cost of living index. Mr. James Douglas considered that the Index of Industrial Production, used separately for each principal industrial group, might serve better to relate workers' pay to their own industry's fortunes. Thus attention could be directed " to means by which wages could be increased without inflation, given all concerned an incentive to increase production and not only to be fair but to be seen to be fair."

A reply points out that such a " system " is already at work in the form of piece-rate payments in most industries, with much closer relationship to the individual or working group. But the real objection to linking pay to production is that industries which do not make any great effort to expand (such as shipbuilding since the war), or those which are forced to contract temporarily through circumstances largely beyond their control (motor vehicles in 1956), would find themselves paying less in wages. They could be faced with a disgruntled labour force, or would find themselves short of labour when demand recovered. Moreover, there is a wide gap between the efficient firm and the average. This would not be reflected except in the payment of higher rates as at present.

Short of a national wage policy the best solution would seem to lie in local action, in other words bargaining at company level, rather than in any new industry-wide system. Already there is too much inflexibility to reflect enterprise, efficiency and hard work.

Spring Fashions

Two more groups of workers have had offers of just over 5 per cent. to settle their spring wage claims. Last week the Joint Industrial Council for the chemical industry agreed an award of 5¼ per cent. for 60,000 unskilled workers. This proposal is bound to affect the wage negotiations of the chemical maintenance workers and about 80,000 I.C.I. employees all of whose rates are up for discussion this week.

Meanwhile, some progress seems to have been made in the coal industry. It is thought that the miners were offered 5 per cent. two weeks ago and that the reaction was somewhat less than enthusiastic. There has now been an offer of around 5½ per cent. which will cost the industry about £10 million a year. Much honour attaches at the moment to the gaining of a vulgar fraction in wages negotiations. It is doubtful if even the Chinese have ever been able to measure " face " in such precise terms.

Picking up the Pieces

The public hearing of the Court of Inquiry in the Shipbuilding dispute has been taken by both sides as a good opportunity to speak out, and a great deal is being said which can help to clear the air. The union's case was briefly stated by Mr. Ted Hill. Companies had five years' work booked and " with each passing quarter the order book is getting larger." The unions were not against the introduction of new methods and would welcome further modernisation. But profits were high, share prices were rising, so was the cost of living, and therefore why not wages? The Shipbuilding Employers Federation, through Mr. N. A. Sloan, went on longer and were rather more interesting. All the familiar statistics were quoted—a 10 per cent. increase in wages would cost £6 million a year, and the Japanese orders had risen by 2·4 million tons compared with 900,000 tons in the United Kingdom (but their delivery delays surely not yet to five years). A long list of restrictive practices was then produced, including demarcation disputes, refusal to operate new machinery, and so on.

It is good that all pent-up feeling should come out. After such an unburdening the two sides may well get together to hammer out something sensible. But, alas, British shipbuilding is hardly likely to become efficient—with or without Mr. Hill—unless a great deal more money is invested in new plant and equipment. Less than £5 million per annum has been spent on " modernising the yards " since the war, and the industry does not envisage spending more than £67·5 million " in the next few years." If this rate of investment were trebled, it might be possible to reduce the time required to build a tanker from the 2½ years needed at present to the 10 months said to be required by German yards.

Rising German Wages

There are signs that the burden of wage costs in Western Germany is rising as quickly as in this country. Earnings per hour in 1956 were 10 per cent. higher there than in 1955 compared with a rise of 8 per cent. in Britain. British engineering wages went up from 57·4*d.* per hour to 62·1*d.* last year. In Germany they increased from 43*d.* to 47*d.* Since there is a much greater burden on German industry in the way of social service payments, however, it is likely that the two wage structures were moving up at about the same rate.

There is some comfort in this but not a great deal. It is apparent that Germany is at last feeling the impact of full employment but although this is reflected in rising wages the German level starts lower. It is small comfort to a man who gets knocked down by a bus that the man behind was running just as fast. It appears too that output per worker rose in Germany last year whereas it receded slightly here. Hours worked in the investment industries also went up by 5 per cent. Thus the Germans had some increase in productivity to set against rising wages.

German engineering prices last year went up by about 3 to 5 per cent., which is comparable with the British performance. But this rise in Germany had been preceded by two years of declining prices, whereas in this country there had been a continuous rise. The fact is that Germany is feeling the same kind of inflation as this country but because it has had a period of falling prices and has a very favourable external trade balance, it has much better reserves to call into play. Here, reserves are already mobilised.

Choosing a Successor

At the British Institute of Management conference at Droitwich last week, Mr. S. F. Steward gave an address called " Preparing for To-morrow's Problems." He wound up his remarks by emphasising the need for men to be picked for responsible positions early and to be promoted just before they are ready for them. In other words, it is best for the man and the job if the new appointee is slightly overloaded at the time of his promotion. This is a modern and more sophisticated version of the remark that a man should be thrown into the pool and be made to swim out.

There is much to commend it. Such circumstances force a man to rise to the occasion—if he can. If he cannot, there is much to be said for the view that he is not marked out for top responsibility. As Mr. Steward was prepared to admit, however, the problem is only half that of finding the right juniors for promotion—difficult as that may be. The really awkward task is to persuade the senior man to stand down. In the circumstances of to-day, many men are fit enough to carry full responsibility well beyond the age of sixty-five. There is every incentive for an active man to work when he is beset by inflation on his pension and savings.

Too little attention, however, is given to the need to spread good management material more evenly and to encourage it to move around while it is still quite young. Too often this problem of management recruitment is seen as a question of training bright young men to fill old men's shoes. It would be much better in these days of scarce management ability if it were given encouragement to pioneer in other jobs. It is a hard doctrine for the organisation that has trained them but it would make better managers.

Information or Ammunition

An article in the latest issue of *Guys Hospital Gazette* draws attention to the large number of doctors who have recently emigrated, and in particular to the Dominions. Going through the Guys list of resident British subjects the emigration rate works out at 7 per cent. The rate seems to have been particularly high among those qualifying in 1952 and 1953, in other words among those who took up the study of medicine just after the war and who therefore tended to qualify rather late.

This kind of survey work can qualify either as information or ammunition. There is little doubt that the last is its main purpose. The facts as published say little more than that quite a number of doctors have emigrated. Whether the numbers are a really significant proportion it is difficult to say. What is important is that this kind of ammunition inevitably gets stored and used at a time such as the present when the doctors are in open dispute with the Ministry of Health about the National Health Service.

Professional men are thus brought into a public argument where all arguments are grist to someone's mill. Men who would not countenance the interpretation of certain limited facts in a certain way in their professional work become rather more opportunist as the argument gathers warmth.

Student Spending Habits

A survey has been made at Glasgow and Birmingham Universities of student expenditure, showing how much they spend on entertainment, tobacco, drink and holidays. The survey has been carried out by the Scottish Union of Students under the guidance of Glasgow University's Department of Social and Economic Research. The findings show that non-residential medical students at Glasgow spend most heavily on clothes and drink but that Birmingham students spend more on drink than Glasgow students, though most students do not drink at all. Glasgow medical men were the heaviest smokers. One may well ask in all this what has happened to the vaunted prowess of the divinity and engineering students.

It may have been that those engaged in the work hoped to discover some disparate results by comparing the residential and non-residential students in the two universities. An even more interesting comparison would be to compare, if that is possible, the two surveys against the very different backgrounds, of the two institutions. Glasgow had a tradition of student life (based on the proverbial bag of oatmeal which the student brought with him) long before Birmingham was any more than a village. Birmingham's student life is much more an expression or reaction to Midland conditions than ever Glasgow can hope to be for Clydeside. There will be plenty of respectable engineers who will lament the thought that the great " chronics " of yesteryear are to have for an epitaph a social survey.